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VOLUME 106(2): AUGUST 2009

CONTENTS

EDITORIAL 133

ON THE DIURNAL ADVERTISEMENT CALL FREQUENCY OF *HEMIDACTYLUS FRENATUS* WITH ADDITIONAL REMARKS ON THE DISTRESS CALL AND CHURR CALL
Dieter Gramentz 135

EARLY STAGES OF THE TRAVANCORE EVENING BROWN *PARANTIRRHOEA MARSHALLI* WOOD-MASON (SATYRINAE, NYMPHALIDAE, LEPIDOPTERA), AN ENDEMIC BUTTERFLY FROM THE SOUTHERN WESTERN GHATS, INDIA
S. Kalesh and Satya Krishna Prakash 142

A NEW REPORT OF *CEPHRENES ACALLE* HOPFFER (LEPIDOPTERA: HESPERIIDAE) FROM SOUTHERN WESTERN GHATS, WITH NOTES ON ITS NATURAL HISTORY AND IMMATURE STAGES
S. Kalesh and Satya Krishna Prakash 149

FAUNAL DIVERSITY OF CLADOCERA (CRUSTACEA: BRANCHIOPODA) OF LOKTAK LAKE (A RAMSAR SITE), MANIPUR (N.E. INDIA)
B.K. Sharma and Sumita Sharma 156

OPISTHOBRANCH FAUNA OF LAKSHADWEEP ISLANDS, INDIA, WITH 52 NEW RECORDS TO LAKSHADWEEP AND 40 NEW RECORDS TO INDIA: PART 1
Deepak Apte 162

BREEDING ECOLOGY AND NEST-SITE SELECTION OF YELLOW-BROWED BULBUL *IOLE INDICA* IN WESTERN GHATS, INDIA
P. Balakrishnan 176

DIVERSITY OF SPIDERS IN GROUNDNUT CROP FIELDS IN VILLAGE AREA OF SAURASHTRA REGION
Varsha Trivedi 184

DISCOVERY OF A BREEDING GROUND OF THE GREATER ADJUTANT *LEPTOPTILOS DUBIUS* AND THEIR CONSERVATION IN THE FLOODPLAINS OF BIHAR, INDIA
Arvind Mishra and Jai Nandan Mandal 190

NEW DESCRIPTION

A NEW SPECIES OF *BRACHYMERIA* WESTWOOD (HYMENOPTERA: CHALCIDIDAE) ON RICE SKIPPER, *PARNARA GUTTATA* (LEPIDOPTERA: HESPERIIDAE) FROM SOUTH KASHMIR
Md. Jamal Ahmad 198

REVIEW

CONSERVING BIODIVERSITY OF RAJASTHAN (WITH EMPHASIS ON WILD FAUNA AND FLORA)
Reviewed by Asad R. Rahmani 201

MISCELLANEOUS NOTES

MAMMALS

1. Interaction of the Pig-tailed Macaque *Macaca nemestrina leonina* with other primates in some forests of Assam in North-east India
Anwaruddin Choudhury 202
2. Additional notes on the diet of Sloth Bear *Melursus ursinus* in Mudumalai Tiger Reserve as shown by scat analysis
T. Ramesh, K. Sankar and Qamar Qureshi 204

BIRDS

3. Mysterious characters recorded in Black-headed Ibis *Threskiornis melanocephalus* during breeding season
Rajesh C. Senma and Chirag A. Acharya 206
4. Sighting of Grey-headed Lapwing *Vanellus cinereus* (Blyth) in Hyderabad, Andhra Pradesh, India
R. Sreekar and Rudra Ram 207
5. Occurrence and breeding record of the Forest Owlet *Heteroglaux blewitti* from Yawal Wildlife Sanctuary, Maharashtra, India
Rushikesh A. Chavan and Kishor D. Rithe 207
6. Ultramarine Flycatcher *Ficedula superciliaris* in Kachchh, Gujarat
J.K. Tiwari 208

REPTILES

7. New record of *Brachysaura minor* (Hardwicke and Gray), an Agamid Lizard from Orissa, India
Rina Chakraborty and Gouri Das Gupta 209
8. Observations on unusual foraging behaviour of *Acanthodactylus cantoris* Günther, 1864, in Western Kachchh, Gujarat, India
Manojkumar Pardeshi, V. Vijay Kumar and Sanjay K. Das 209

9. First record of *Protobothrops jerdonii xanthomelas* (Günther, 1889) from Eaglenest Wildlife Sanctuary, India
Amod Zambre, Chintan Sheth, Shashank Dalvi and Nirmal Kulkarni 211

AMPHIBIANS

10. Report on mass mortality of Frogs at Son Chiriya Wildlife Sanctuary, Gwalior, India
Karthikeyan Vasudevan and G. Prudhvi Raj 213

FISH

11. On a record of *Badis badis* (Hamilton) (Teleostei: Perciformes: Badidae) from Tamil Nadu, India
J.D. Marcus Knight and K. Rema Devi 215

INSECTS

12. Taxonomic studies on some species of *Oxya* Serville (Orthoptera: Acrididae) of Kashmir Himalaya
M. Nayyar Azim and Shabir A. Reshi 216

OTHER INVERTEBRATES

13. A preliminary note on the Marine and Estuarine Molluscs in and around Bahuda Estuary, Orissa, East Coast of India
S.K. Pati, D. Mahapatro and R.C. Panigrahy 222

BOTANY

14. *Crotalaria angulata* Miller and *Taxillus bracteatus* (Wall.) Tieghem – new records to the Flora of Orissa
C. Sudhakar Reddy, Chiranjibi Pattanaik and A.K. Biswal 224

15. *Hedychium flavescens* Carey ex Roscoe – an addition to the Flora of Maharashtra State
Nilesh V. Malpure and S.R. Yadav 225

16. Some rare and endangered plant species of Gujarat, India
P.S. Nagar, Sachin Sata and T.D. Pawar 226

Cover Photograph: *Chromodoris fidelis*
By Deepak Apte

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Editorial

Mother Earth or Mother Water

"Whiskey's for drinking, water's for fighting over" — Mark Twain

Though water covers more than 70 per cent of our blue planet, 97 per cent is salty and non-potable. Of the remaining three per cent, two percent is locked up in snow and ice, leaving only one per cent as liquid surface and ground water for use. We use two-third of this one per cent to grow our food.

Decades of misuse, overuse, and pollution of water has left us with a deep water crises. If immediate steps for water conservation are not taken, climate change will further aggravate this crises. Our water demands, and the millions of daily mutinies that we see in our cities, towns and villages everyday over water, will keep growing, as human population adds by 83 million every year. As our country develops, water demands will grow. Water use rises with wealth and changes in life-style. For example, an American uses 100 gallons of water daily, while in dry poor countries, it may be as low as 5 gallons. Forty-six per cent of individuals on our planet do get piped water up to their homes. In some countries, women have to walk up to 8-10 km every day to fetch water. In many towns and villages of India, people have to survive on limited 'tanker-water' as they have already polluted or depleted their water sources.

Human civilization is closely linked to freshwater ecosystems. Cities, towns, villages, industries, thermal power plants, chemical plants, agriculture fields are concentrated alongside water-bodies. Through decades of neglect, the Ganga, Jamuna, Godavari, Sutlej, Sabarmati are dying due to untreated sewage, non-degradable litter, industrial effluents and chemical pollution. For over thousand years, citizens of Delhi received potable water from the Jamuna and wells, but now drinking water for Delhi comes from the Ganga and Beas rivers 400 km away. Similarly, Hyderabad and Secundrabad get potable water from the Krishna 116 km away and Manjira river, 60 km away. The Hussain Sagar built for the twin-cities is now heavily polluted and its water is unfit for human consumption. There are many such examples all over India.

A holistic river-basin approach, with conservation and sustainable-use in mind, should be developed for all our rivers and waterbodies. But looking at the result of the Ganga Action Plan, now renamed the National Ganga River Basin Authority, it appears that we have a long way to go. During the last two decades, Rs. 36,000 crores have been spent on cleaning the Ganga, but the river is as dirty as ever. There is a lack of coordination between the irrigation, hydropower, rural development and environment ministries. Most importantly, there is lack of appreciation of the ecological and environmental role of our rivers and natural water-bodies. Unless we change our thinking, engineering solutions to ecological problems will not save our water resources.

We have to decide whether we want engineering solution to our water crises – megadams, long canals or pipelines, new technology to extract depleting underground fossil water – or, conservation approaches which restore depleted reservoirs and aquifers, protect aquatic ecosystems, stop pollution of rivers, covers catchment areas in natural vegetative, starts sustainable rainwater harvest, and result in equitable and fair distribution of water for all communities, both human and non-humans (plants and animals). We though require new technologies in agriculture (e.g. micro-sprinklers replacing flood irrigation, developing dryland-tolerant crops), pollution cleanup and quick treatment of wastewater, we also have to maintain the minimum ecological flow in all rivers which is required for the basic ecological functions of a river. We have to remember that we cannot achieve 8-10 per cent economic growth in the coming years which the Government of India is hoping, without cleaning our river systems.

Rivers, wetlands and swamps make up less than 0.3 per cent of fresh water and less than 0.01 per cent of all the water on Earth. Yet these waters are home to as many as 1,26,000 of the world's animal species. Almost 43 per cent of the 30,000 known species of fish live in freshwater lakes and rivers. India has about

2,500 fish species, of which 930 species are freshwater inhabitants. Many species have become extinct or locally extinct due to pollution, destruction of their habitat and introduction of invasive species. According to IUCN, freshwater animals are disappearing at a rate four to six times faster than animals on land or at sea, and freshwater fishes are much more threatened with extinction than the sea fishes.

The Himalayan glaciers, covering millions of square kilometers, contain the largest volume of ice outside the polar regions. One third of the human population, nearly two billion people depend on these glaciers as they feed on Asia's famous rivers such as the Ganges, Brahmaputra, Mekong and Yangtze. Climate change and heating of our Planet is threatening these glaciers. The Tibetan plateau as a whole is heating up twice as fast as the global average of 1.3 F over the past century – and in some places even faster. As our planet becomes hotter, the melting of glaciers will increase incrementally as hot air holds more water molecules than cold. Natural melting of glaciers during summer and monsoon plays an important role in maintaining the flow of these rivers which feeds one-third of India's population. On a short term, we may have more water in our rivers, but slowly when the glaciers disappear, little water will be left to feed these mighty rivers.

Marq de Villiers in his book WATER WARS has said that there is enough water for everyone on this planet, it is distribution and use that are the problem. Whether we will clean up our watery mess and learn to use it sustainably, or go to war for the precious remaining clean water, only time will tell.

Asad R. Rahmani

■ ■ ■

ON THE DIURNAL ADVERTISEMENT CALL FREQUENCY OF *HEMIDACTYLUS FRENATUS* WITH ADDITIONAL REMARKS ON THE DISTRESS CALL AND CHURR CALL

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Various aspects of the bioacoustic behaviour of *Hemidactylus frenatus* were studied in November 2007 in Aluthgama, Western Province, Sri Lanka. Markedly increased production of advertisement calls was noted about 30 to 50 min prior to sunset or about 70 to 90 min prior to complete darkness; and during most nights (n=8), peak calling activity was observed during dusk from 1750-1830 hrs, between sunset and complete darkness. Advertisement call activity was found to be much reduced during nights with prolonged rain in comparison to nights without rain, and the difference was statistically significant ($P<0.05$). Minimum number of calls within 7 hours recording was 59 on a rainy night and 208 during a dry night. Average number of advertisement calls on rainy nights was 60.5 (SD=2.12; range: 59-62; n=2), while average number of calls on dry nights was 144.9 (SD=35.7; range: 110-208; n=8). There was statistically significant ($r=0.63$; $P<0.05$) correlation between the number of advertisement calls and average air temperature. The distress call is a short, relatively high-pitched squeak and its average length was 0.041 sec (SD=0.03; range: 0.013-0.080 sec; n=5). Average maximum sound intensity was 89.7 dB (SD=10.69; range: 79.5-105.8 dB; n=5). Maximum sound intensity was reached between 3,967 and 5,443 Hz ($\bar{x}$=4,871 Hz; SD=592; n=5). Maximum recorded frequency was 18,636 Hz, but maximum frequency can be as low as 12,455 Hz with an average of 14,835 Hz. Lowest call frequencies ranged from 554 to 1,199 Hz ($\bar{x}$=904 Hz; SD=287; n=5). The snare-like churr call was structured as a number of 6 pulses. Pulse lengths varied between 0.006 and 0.007 sec ($\bar{x}$=0.0063 sec; SD=0.005; n=6), and time gaps between pulses were 0.021 to 0.026 sec ($\bar{x}$=0.023 sec; SD=0.003; n=5). Churr call length was 0.160 sec and maximum sound intensity was 76.4 dB reached at 5,440 Hz. Minimum and maximum frequency was 369 and 15,869 Hz respectively.

Key words: *Hemidactylus frenatus*, bioacoustics, advertisement call, distress call, churr call, Sri Lanka

INTRODUCTION

For many decades the presence of a voice in geckos has been well-known. However, it was not until 1968 and 1969 when the first analysis of advertisement calls in barking geckos *Ptenopus garrulus* and *P. kochi*, respectively, were carried out by Haacke. Since then advertisement calls have been the subject of research in a number of gecko genera, e.g., *Ptyodactylus* (Frankenberg 1973; Werner *et al.* 1978), *Hemidactylus* (Marcellini 1974, 1977b; Frenkel 2006), *Tarentola* (Nettmann and Rykena 1985) and *Thecadactylus* (Gramentz 2007b). Another gecko call on which bioacoustical research is concentrated is the distress call. Distress call was studied by Frankenberg (1975, 1978), Gramentz and Barts (2004), Gramentz (2004, 2005b, 2005c) and Barts (2006). Brown (1984/85) even noted an ultrasound component in the distress call of many gecko species.

Hemidactylus frenatus is a familiar house gecko species and known to be vocally very active. The advertisement call of *H. frenatus* is well-known and they are even called "*tinktock*" or "*tschicktschack*" (Manthey and Grossmann 1997). The advertisement call of *H. garnotii*, another well known call, is called "*tjik tjak*" in Malaysia (Steck 1908). According to Daniel (1983), the species is perhaps the noisiest of Indian geckos. Territorial advertisement calls are supposed to be the means for spacing themselves out to claim areas for feeding and breeding.

Despite the well-studied structures of the different calls of *H. frenatus* (Marcellini 1974, 1977a) not much is known on its diurnal rhythmicity. Hediger (1934) briefly mentioned that *H. frenatus* not only calls during dusk, but occasionally also during the day. The species was reported by McCann (1940) from Sutgutti, India, to be very vociferous in June and calling frequently at intervals all night. Another mention of the voice of *H. frenatus* stems from Poulin *et al.* (1995), which reported "growl calls" during aggressive interactions.

While describing the different calls of *H. frenatus*, Marcellini (1974) did not name them according to the behavioural context in which the calls were used, but instead differentiated them by their sound effect and number of syllables emitted (e.g. churr call, single chirp call, multiple chirp call). Marcellini (1974) roughly reported that the distress call is very short, < 0.05 sec, and that it begins and ends abruptly. The dominant frequency is approximately 2,000 Hz, with harmonics at 1,000 Hz interval above the dominant frequency. He only published audiospectrograms and these

were very much compressed on the time scale and did not allow a proper call structure analysis. Until now the calls of *H. frenatus* were studied only in subpopulations into which the geckos were introduced by human activities, such as Mexico (Marcellini 1974) and Costa Rica (Frenkel 2006). The present study will show aspects of the species' bioacoustic behaviour in its native environment.

MATERIAL AND METHODS

To evaluate overall advertisement calling activity from one location, Aluthgama, western Sri Lanka (6°25'48.89 N; 79°59'54.35 E), all advertisement calls of *H. frenatus* which could be heard were noted. Recording time was between 1700 hrs and 2400 hrs. Time of dusk, sunset and total darkness was noted. Additionally the air temperature was recorded at 30 min intervals starting at 1700 hrs and ending at 2400 hrs resulting in 15 measurements per night. The digital thermometer was installed with a thermocouple at a height of 2 m. Furthermore, weather and meteorological parameters as clear and overcast sky, rain and thunderstorms were also noted. Recording dates were eight consecutive nights from November 08 to November 15, 2007 and another two consecutive nights on November 23, and November 24, 2007. Judged from the various different directions of which the calls could be heard, they possibly came from about 10-15 male *H. frenatus*.

Additionally five distress calls and a churr call were recorded and analysed. The recording equipment is the same described by Gramentz (2005a, c). The sound card used was Creative Soundblaster Audigy 2 ZS Platinum Pro with a sample rate of 44,100 Hz, 16 bit. Various softwares were used for sound analysis, such as Avisoft-SASLab, Creative WaveStudio and Raven1.2. Air temperatures at which the calls were recorded ranged from 27.6-30.6 °C (Table 1). Distance from the geckos to the microphone while recording churr and distress calls was 5-10 cm.

Terminology was used as in Gramentz (2003, 2008), however, "churr call" was adopted from Marcellini (1974).

RESULTS

Advertisement Call

As previously described by Marcellini (1974) a repertoire of three different call types could be identified in *H. frenatus* in Sri Lanka. The production of these calls was clearly situation dependent. Directly during an aggressive encounter between two males, a short trill-like call can be produced. This "churr call" is emitted when one male chases another in order to drive it away from its territory. Threat and distress calls are emitted in the emotional state of fear.

Table 1: Air temperatures at which advertisement calls of *Hemidactylus frenatus* were recorded at Aluthgama, Western Province, Sri Lanka

Date	$\bar{x}$ (°C)	SD	Range (°C)
Nov. 08, 2007	25.7	1.08	24.5-27.4
Nov. 09, 2007	27.5	1.00	26.1-29.6
Nov. 10, 2007	27.7	1.04	26.3-29.9
Nov. 11, 2007	27.4	1.54	25.0-31.0
Nov. 12, 2007	25.9	1.65	24.4-29.0
Nov. 13, 2007	28.3	1.40	26.3-31.6
Nov. 14, 2007	27.4	2.04	25.0-31.9
Nov. 15, 2007	27.1	1.51	25.4-30.2
Nov. 23, 2007	27.6	1.25	25.9-30.3
Nov. 24, 2007	27.3	1.60	25.9-30.9

Besides night time, *H. frenatus* produces advertisement calls during the day, but comparatively rarely. Calls of this type were noted during daylight at morning (e.g., 0838 hrs), midday (e.g., 1302 hrs), and afternoon (e.g., 1514 hrs) hours.

It showed that calling activity started about 30 to 50 min prior to sunset or about 70 to 90 min prior to complete darkness. During most nights (n=8) peak calling activity was noted precisely at 1750-1830 hrs (Fig. 1b; f to j) between sunset and complete darkness or just before sunset (Fig. 1e), or at complete darkness (Fig. 1a). In just two cases, the calling activity pattern showed a different distribution (Fig. 1c, d). On all days a sharp increase in calling activity could be observed from about 1700 and 1730 hrs onwards. On two consecutive nights of November 10 and 11, 2007 (Fig. 1c, d) the pattern of calling was different from other nights, but similar on these two nights. Here peak calling activity was at about 2115 hrs and 2130 hrs respectively, i.e., a shift of three to three and a half hours in comparison to most other nights.

At times a kind of dynamics in the production of calls can be heard. These may result in short peaks in calling activity. Example, two males respond to the advertisement call of one male, followed shortly by other males in hearing distance. So, occasionally a fairly large number of calls (e.g., 8 calls in 5 minutes) can be heard in a rather short time from different directions. After some time when most males in the vicinity have produced one or two response calls, call frequency is reduced to a lower rate until this kind of escalation pattern repeats. The result is a rather wavy appearance of calling activity during the recording time.

Beside the reaction of replying to an advertisement call there is another situation when such a call is emitted. A number of times I observed that one advertisement call is produced after a male gecko successfully chased away an intruder from his territory. The victorious gecko immediately returned to his territory, formed an arch with its body and emitted a call. Each call is accompanied by a strong exhalation of air from the lungs that can be easily observed from the side.

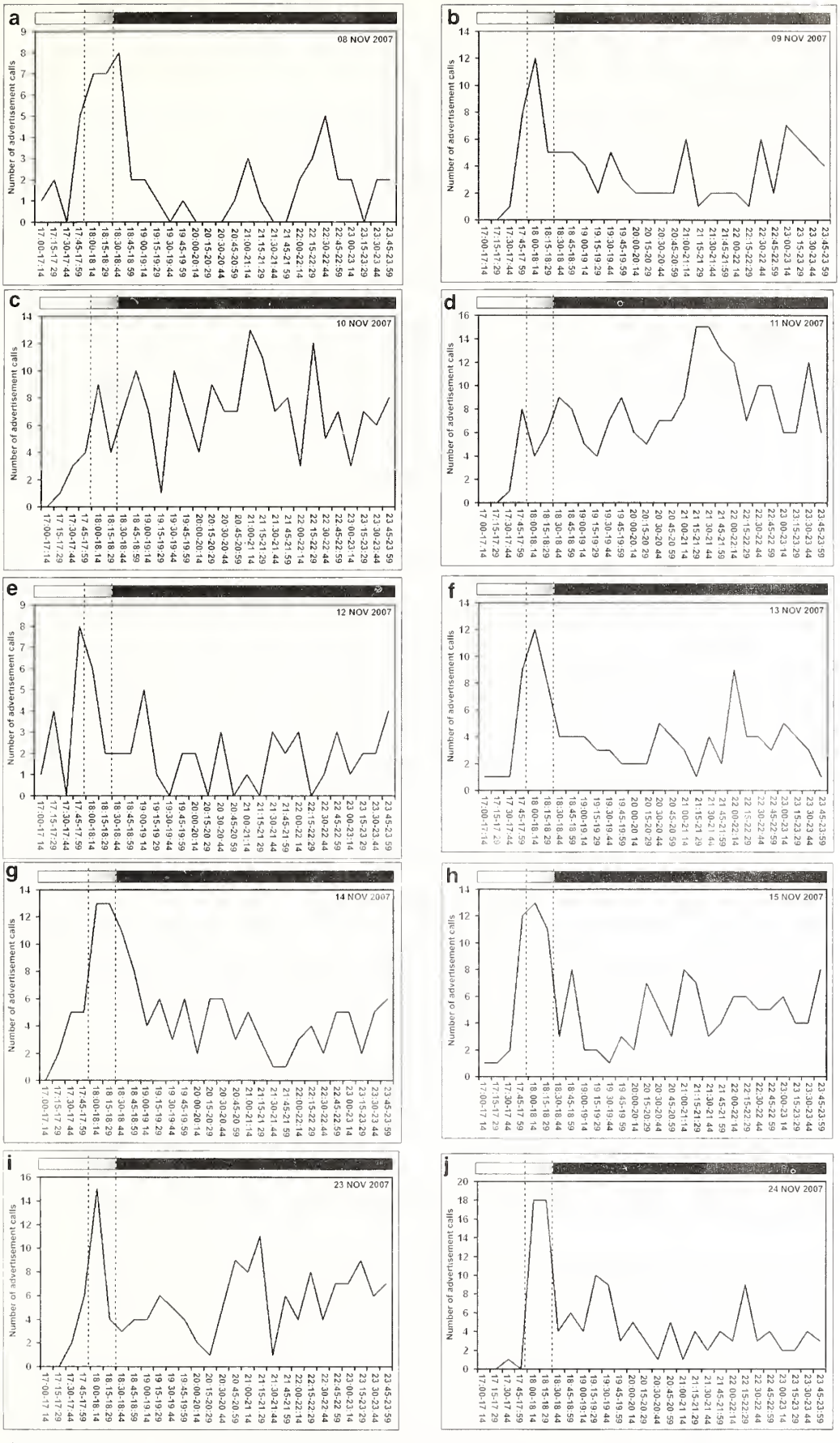

Fig. 1 a-j: Frequency of advertisement calls of *Hemidactylus frenatus* from Sri Lanka during different nights
Left dotted line marks the time of sunset, right dotted line marks point of complete darkness

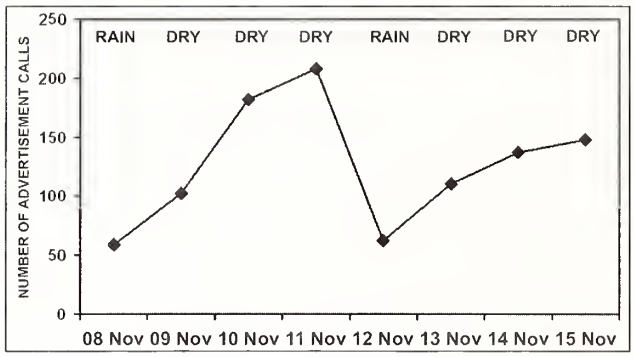

Fig. 2: Variation of the advertisement call activity of *Hemidactylus frenatus* from Sri Lanka during rainy and dry nights

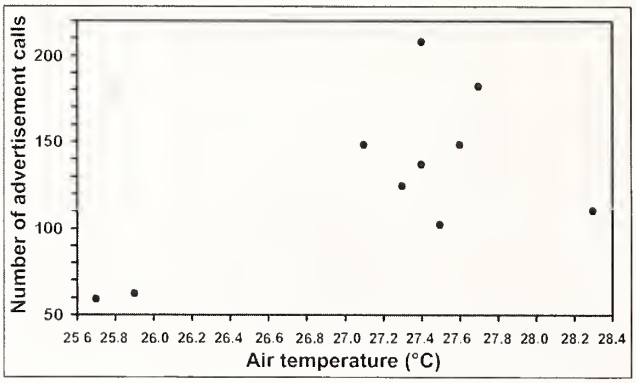

Fig. 3: Relationship between advertisement call frequency of *Hemidactylus frenatus* and air temperature during 10 nights

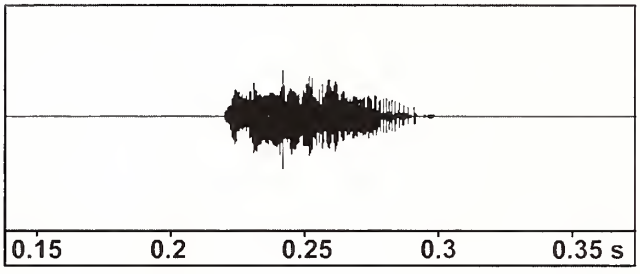

Fig. 4: Oscillogram of a distress call of a male *Hemidactylus frenatus* from Sri Lanka. Length of the call is 0.083 sec

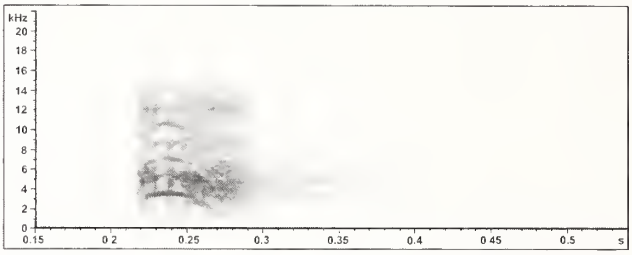

Fig. 5: Audiospectrogram of a distress call of a male *Hemidactylus frenatus* from Sri Lanka. Length of the call is 0.080 sec. The harmonics are at the frequencies 3,414 Hz, 5,351 Hz, 7,012 Hz, 8,765 Hz, 10,425 Hz, 12,086 Hz, 13,898 Hz and 15,592 Hz

Advertisement call activity is very much reduced during nights with prolonged rain in comparison to nights without rain. Minimum calling activity was 59 calls on November 08, during the seven hours recording, of which it was raining for 1 hr 33 min. On November 12, it rained for 1 hr 8 min, and 62 calls were recorded. Maximum number of calls (208) was recorded on November 11, a dry night. Average number of advertisement calls during rainy nights was 60.5 (SD=2.12; range: 59-62; n=2). Average number of calls during dry nights was 144.9 (SD=35.7; range: 110-208; n=8), and there is a statistically significant difference ($P<0.05$; $t=3.197$, t-test) between the means of advertisement calls on rainy and dry nights. Overall average was 128 calls between 1700-2400 hrs in 10 nights.

Call activity seems to be influenced by the weather, since there was increase in calling activity on dry nights with a sharp drop when these were interrupted by a rainy night (Fig. 2). Furthermore, call activity was positively related to air temperature. There was a modest but statistically significant ($r=0.63$, $P<0.05$) correlation between the total number of advertisement calls and average air temperature during the night (Fig. 3).

Distress Call

The distress call is a very short high pitched sound (Figs 4 and 5). The average length of the recorded calls was 0.041 sec (SD=0.03; range: 0.013-0.080 sec; n=5).

Maximum sound intensity varied between 79.5 and 105.8 dB. On an average maximum sound intensity in the five recorded distress calls was 89.7 dB (SD=10.69).

Maximum recorded frequency ranged from 12,455-18,636 Hz, with an average of 14,835 Hz. Lowest call frequencies varied between 554 and 1,199 Hz having an average of 904 Hz (SD=287; n=5). The average of maximum frequency in the five distress calls was 14,835 Hz. Despite the wide frequency span of about 11-18 kHz in the recorded distress calls the span at which the maximum sound intensity is produced covers a rather small range of about 1.5 kHz. Maximum sound intensity was found to be between 3,967 and 5,443 Hz (Figs 6 and 7). The average frequency at which maximum sound intensity was noted was 4,871 Hz (SD=592; n=5).

The distress call of *H. frenatus* shows rather similar intervals between harmonics. The average interval between harmonics of the distress call shown in Fig. 5 was 1,740 Hz (SD=104.2; n=7). The interval between harmonics ranged from 1,660 Hz to 1,937 Hz. Frequency of the lowest and at the same time strongest harmonic was 3,414 Hz. The highest harmonic had a frequency of 15,592 Hz.

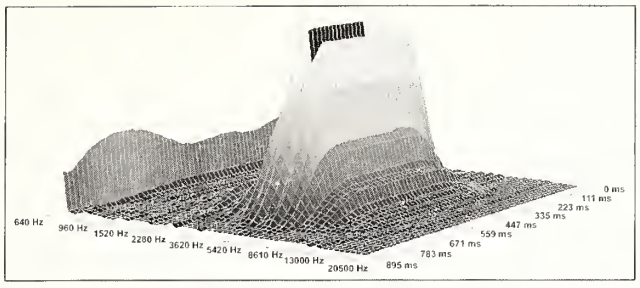

Fig. 6: Three-dimensional logarithmic image of a distress call of individual-a *Hemidactylus frenatus* (male)

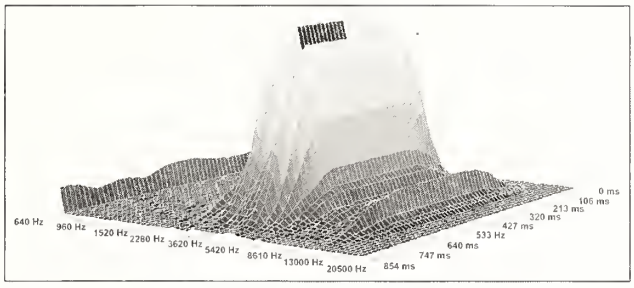

Fig. 7: Three-dimensional logarithmic image of a distress call of individual-b *Hemidactylus frenatus* (male)

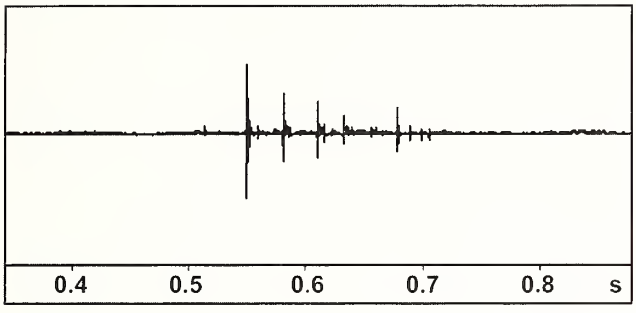

Fig. 8: Oscillogram of a churr call of a male *Hemidactylus frenatus* from Sri Lanka. Length of the call is 0.160 sec

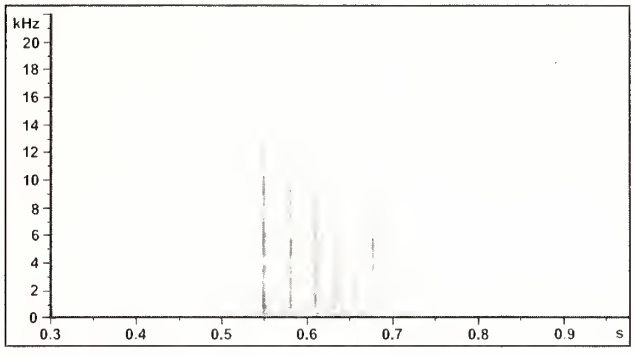

Fig. 9: Audiospectrogram of the same churr call of a male *Hemidactylus frenatus*

Churr Call

The churr call consists of six stronger distinguishable pulses, which can be identified in the oscillogram and audiospectrogram (Figs 8 and 9). The length of a pulse varies between 0.006 and 0.007 sec ($\bar{x}$=0.0063 sec; SD=0.005; n=6). The time gap between these pulses varied between 0.021 and 0.026 sec ($\bar{x}$=0.023 sec; SD=0.003; n=5).

The single churr call had a length of 0.160 sec. Maximum sound intensity was found to be 76.4 dB, which was less than in the weakest distress call. Maximum sound intensity was however reached at 5,440 Hz within the range of the recorded distress calls. The lowest calling frequency was measured in the churr call with just 369 Hz, but maximum frequency of 15,869 Hz was comparable to the range of the distress call.

DISCUSSION

Marcellini (1974) recorded advertisement calls (multiple chirp calls in his terminology) of *H. frenatus* per hour in Mexico during five consecutive nights and condensed the results into one graph. He also noted an increase in calling activity at his starting point at 1800 hrs. However, he observed a steady increase in calling activity in the geckos from Mexico with a peak at about 0330 hrs in the night. The early increase in calling activity around sunset resembles the findings from Sri Lanka, but contrary to the geckos from there, there was no marked peak early after this initial calling activity. Obviously there is a geographical difference in peak calling activity between the two locations. Also in *Ptenopus garrulus* peak calling activity was noted at sunset when darkness increases (Brain 1962). According to Loveridge (1947), *P. garrulus* calls during the short period of twilight. The phenomenon that *H. frenatus* may show different peak calling activities requires further investigation from other geographically different locations.

I have the impression, although this is not yet confirmed by direct observation of a certain individual, that a male may give his first advertisement call just about the same time when it starts activity for the night. Also, Marcellini (1974) reported that after emergence from their diurnal retreats, geckos commonly called before moving to their feeding areas. It is obviously of major importance for the geckos to announce territoriality prior to the start of nocturnal activity. As in this study, Manthey and Grossmann (1997) noted that calls of *H. frenatus* can also be heard during the whole day, and Marcellini (1974) wrote that few calls occur during daylight hours. As in this study, also Frenkel (2006) found that call activity of *H. frenatus* studied in Punta Morales, Costa Rica, was positively correlated to air temperature at night.

Advertisement calls which are formed by a large number of rather identical syllables are known from other *Hemidactylus* species: *H. angulatus* (Gramentz 2005d), *H. mabouia* (Gramentz 2003; Regalado 2003), *H. platyceplialus* (Gramentz

2005a) and *H. turcicus* (Marcellini 1977a; Frankenberg 1982). Furthermore, this rather stereotyped territorial call is known from other genera as *Phyllodactylus* (Marcellini 1977b), *Ptenopus* (Haacke 1968, 1969; Gramentz 2008), *Ptyodactylus* (Frankenberg 1973, 1974), *Tarentola* (Nettmann and Rykena 1985) and *Thecadactylus* (Gramentz 2007b). Multiple chirp calls can, however, also have a submissive function as in *Cosymbotus platyurus* (Gramentz 2007a).

From *H. angulatus* and *H. platycephalus* another call consisting of a large number of syllables is known (Gramentz 2005a, d). This contact call has a rather weak sound intensity and is displayed by the male in close male – female interaction. It would be very interesting to know whether this type of call is also a part of the repertoire of *H. frenatus*.

Marcellini (1974) wrote that the distress call (his single chirp call) is less than 0.05 sec long. In the present study, it showed that this type of call is indeed very short in duration. In fact, the shortest calls were just 0.013 and 0.016 sec long, however, two distress calls had lengths of 0.060 and 0.080 sec. He also noted that some calls can only be heard from a few metres away while others are clearly audible from 10 m. This is reflected in the very different sound intensities of 79.5 to 105.8 dB. Like him, I cannot explain the reason for these variations in sound intensity in the distress call. Distress calls are already known from other gecko species to vary in length. In *Stenodactylus stenurus*, three different distress calls were noted varying mainly in length, but also in sound intensity (Gramentz 2004).

Possibly due to the equipment used by Marcellini (1974) he got the impression of distress calls abruptly beginning and ending. However, as shown in Fig. 3 the intensity increases to a maximum after 0.22 sec. The call ends in a kind of tail in which even single pulses can be identified. In comparison, a distress call actually having an abrupt beginning and ending is for example produced by *Haemodracon riebeckii* (Gramentz 2005b). There are also some differences in the overall frequencies and intervals in the distress calls recorded at Sri Lanka and the data reported by Marcellini (1974) from Mexico. He mentioned as the dominant frequency 2,000 Hz with harmonics at 1,000 Hz intervals. In Sri Lanka, this frequency was higher (3,414 Hz) and the interval between harmonics averaged 1,740 Hz.

According to Marcellini (1974) the churr call is an infrequently heard vocalization and he recorded twice of which both were less than 0.2 sec long. I also recorded this kind of short call duration, having a length of 0.16 sec. He further observed that the churr call was audible from a distance of 35 m. As this type of call was the weakest recorded at Sri Lanka, it is likely that, similarly as in the distress call, a high variation of sound intensity exists. The growl calls reported by Poulin *et al.* (1995) are most probably identical to the churr calls first described by Marcellini (1974).

Only males were found to emit churr and distress calls at Sri Lanka. Marcellini (1974) reported that only males emitted churr calls and this is consistent with the findings of *H. frenatus* at Sri Lanka.

Marcellini's (1974) sound analysis equipment seems to be restricted in detecting frequencies above 8,500 Hz as his graphs of audiospectrograms showed maximum values of 6 or 8 kHz on the y-axis. Therefore, the impression appears that the call frequencies reach their full capacity within this range. This is, however, not the case. Both the churr and distress call reach frequencies above 15 and 18 kHz respectively (Figs 5, 6, 7 and 9).

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EARLY STAGES OF THE TRAVANCORE EVENING BROWN *PARANTIRRHOEA MARSHALLI* WOOD-MASON (SATYRINAE, NYMPHALIDAE, LEPIDOPTERA), AN ENDEMIC BUTTERFLY FROM THE SOUTHERN WESTERN GHATS, INDIA

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Descriptions of hitherto unknown early stages of the Travancore Evening Brown *Parantirrhoea marshalli* Wood-Mason, a rare and endemic butterfly from the southern Western Ghats are presented. *Ochlandra travancorica* Benth., Family Poaceae, a gregarious reed seen near water in deciduous and mixed forests, is reported as its larval host plant for the first time. Even though the caterpillars of this species were found to be common in suitable habitats, the adults were rarely sighted in its range.

Key words: early stages, endemic species, Travancore Evening Brown, *Parantirrhoea marshalli*, Satyrinae, Nymphalidae, Lepidoptera, Western Ghats

INTRODUCTION

Travancore Evening Brown *Parantirrhoea marshalli* was first described in 1880 by J. Wood-Mason in *The Journal of Asiatic Society*, Bengal. Marshall and de Niceville (1883) stated, "*P. marshalli* has yet only been found in Travancore, where it was discovered by Mr. H.S. Ferguson on the Ashamboo hills in May." More than 100 years have passed with only a handful of sightings of this elusive butterfly.

Parantirrhoea marshalli is endemic to the southern Western Ghats of peninsular India and is known to occur from Coorg to the Ashambu hills. This species could be described as an entomologic curiosity because it's nearest related genus *Antirrhoea* is found flying only in the South American jungles. Both these genera are remarkable for the peculiar arrangement of hindermost veins of the anterior wings. Here, the first median veinlet runs back to the inner angle and the submedian vein ends a considerable distance short of that angle.

The species had not been reported since its last sighting by Fraser in 1930 till Elamon (1993) rediscovered a population of *P. marshalli* in the environs of the Periyar Tiger Reserve in Kerala. Recently, Kunhikrishnan (2002) reported sightings of this butterfly in the southern region of the Western Ghats. Although both sexes of this butterfly have been photographed, not much information is available on the early stages of this butterfly.

A number of authors have written about the perfect form of this species; but the only mention of its suspected host plants and early stages are in Fraser (1930), Yates (1931), and Wynter-Blyth (1957), Gaonkar (1996). Fraser (1930) mentioned that the larva of *P. marshalli* feeds on 'cane'. Yates (1930) enquired, through the *Journal of the Bombay Natural History Society*, if what Fraser (1930) meant by 'cane' was *Ochlandra rheedii* Benth. & Hook.f. ex Gamble, and asked him to describe the larva if he had found it.

Wynter-Blyth (1957) quoted Yates in his work BUTTERFLIES OF THE INDIAN REGION and suspected that the food plant was *Ochlandra rheedii* (Syn: *Ochlandra scriptoria* Dennst.), as it was always in its clumps that Yates had found it. Gaonkar (1996) stated that the bamboo *Ochlandra scriptoria* Dennst. could be a probable larval host plant for *P. marshalli* and the species was invariably found wherever this plant was available.

METHODOLOGY

This study was conducted in the Kallar-Ponmudi valley (8° 60'-8° 79' N; 77° 07'-77° 20' E); a northerly extension of the Ashambu hills of southern Western Ghats in Trivandrum district of Kerala state in southern India (Fig. 1).

The climate of the area is best described as tropical monsoon type. The mean annual rainfall, from the South-west Monsoon (May to July) and North-east Monsoon (October to November), is around 3,000 mm. The dry months of the year are from January to May. The maximum summer temperature is 35 °C and minimum winter temperature is 16 °C.

The larvae collected from field were reared under laboratory conditions from January to August 2006. 18 larvae were reared to final instar larvae (Table 1). Caterpillars collected were reared in suitably-sized plastic containers, for example, a 3 cm long caterpillar was reared in a container 9 cm x 6 cm x 6 cm in size. Holes of 1 mm x 1 mm per sq. cm were provided for sufficient aeration and maintaining

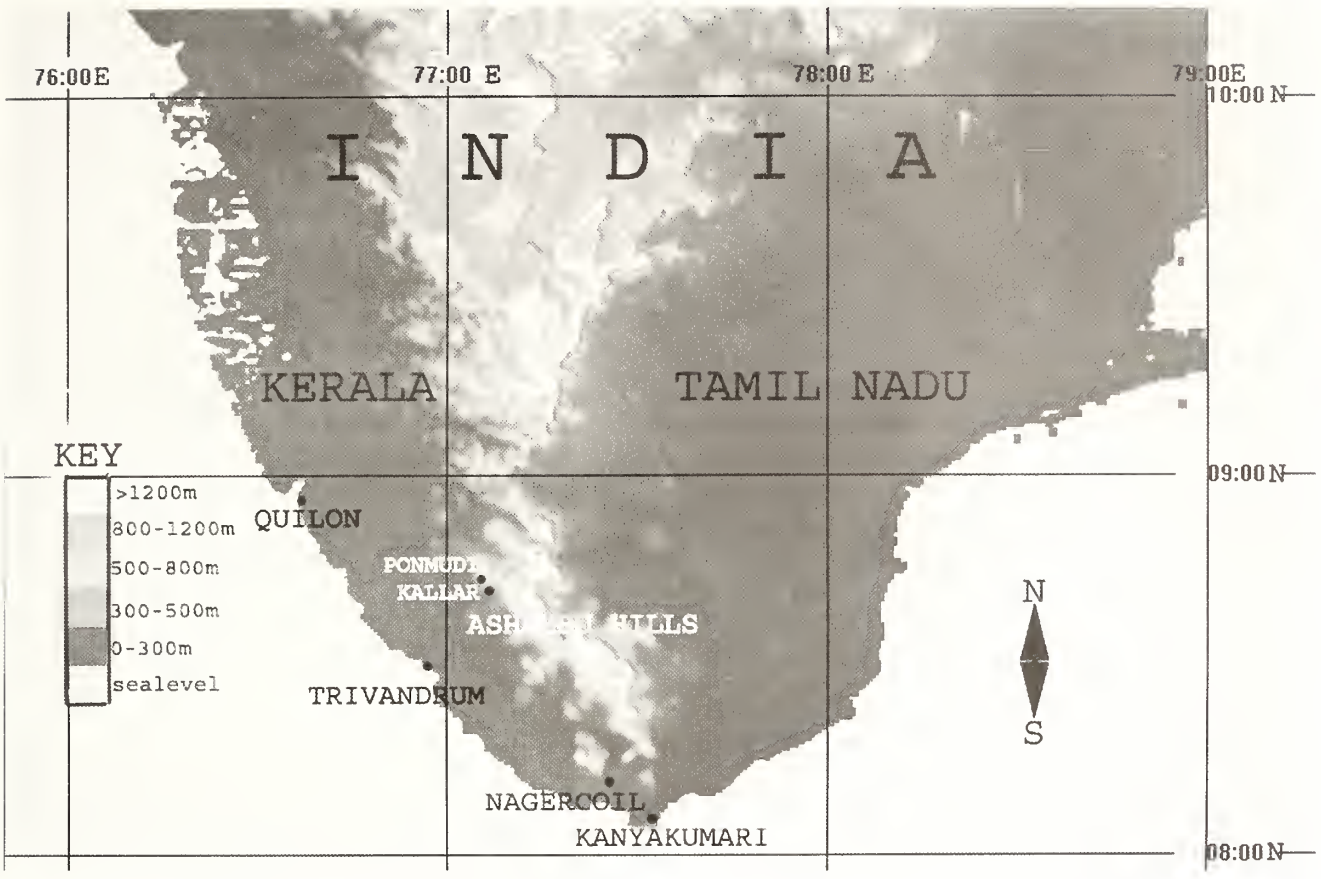

Fig. 1: Map of the study location: Kallar-Ponmudi region in Southern Western Ghats of southern India

appropriate humidity. The container was cleaned and fresh leaves were added every day. Biometric data was obtained with Vernier callipers.

For description of larvae, we have followed Bell (1909). We have described the stage before the first moult as newly hatched larva. The area between the sub-dorsal and dorso-lateral aspects of the larvae are described here as paradorsal

Table 1: Details of the larvae found and reared of *Parantirrhoea marshalli* Wood-Mason 1880 (January to July 2006, N=18)

S.No.	Month and year	Number of larvae per leaf observed in field	Instar
1	January 2006	1	4th instar
2	February 2006	1	Final instar
3	March 2006	1	Final instar
4	April 2006	3	All egg larvae
5	April 2006	2	Both 4th instar
6	June 2006	2	Both 4th instar
7	June 2006	1	Final instar
8	July 2006	2	2nd instar
9	July 2006	1	2nd instar
10	July 2006	2	Both 1st instar
11	July 2006	2	Both Final instar

region. The larvae were exacting in their needs and were difficult to rear in laboratory conditions. The adults were photographed and released into their natural habitats.

RESULTS

Parantirrhoea marshalli larvae were collected from a homestead near a large reed-break in Kallar valley in January 2006, at an altitude of less than 300 m above msl. Ferguson (1891) mentioned *P. marshalli* in his list of Travancore butterflies, and wrote that he had taken the adults from *Etah* jungle – *Bheesha travancorica* Bedd. (Syn: *Ochlandra travancorica* Benth.) in July. We collected the caterpillars from an *Etah* jungle-like habitat.

Egg: Structure unknown. Eggs were laid on the underside of the leaves almost towards the midrib, in batches of 2-4. The larvae were almost always found in small batches. On four occasions the remnants of eggshells were observed on the underside of the leaves.

Newly hatched larva: Head capsule is shiny black and shaped like in *Melanitis*, but slightly higher and without horns or other ornaments. Head capsule bears small, blackish hairs. Body is spindle-shaped and ends in a bifid tail.

The body is fluorescent yellowish-green with a tinge of yellow, especially on the dorsum. Lateral part of the body is bright leaf green. The tail is black and held at an acute angle with the substratum. The larvae on the same leaf lay huddled parallel to the midrib of the leaf. They usually fed a little away from where they lay. The general pattern of eating was peculiar. The larva lays a silk track that it follows to feed and returns to its original resting place near the midrib. The leaves are cut straight from the margin to the midrib – the primary cut, and then eaten from the side the cut was made. This pattern of foraging continued to the last instar. It was easy to locate the larvae because of their characteristic eating pattern (Fig. 2a).

First instar larva: The first instar larva is similar in structure and habits to the newly hatched larva, but differs slightly in coloration. The head and hair on it are black, except perhaps on the vertex, where there is a clear space roughly rhomboidal in shape; this bare area is greyish. The body appears more brightly coloured, and the last abdominal segment is black. The tail processes are curved upwards and always found diverging from each other (Fig. 2b). The eating patterns are similar to the newly hatched larva, and they retain the gregarious resting habits of the earlier instar.

Second instar larva: This instar is similar to the first instar larva in colour and structure, except for the head, which is greenish-yellow with vertical stripes like in the later instars. The pair of fluorescent yellow paradorsal stripes seen in later instars is a single fused dorsal stripe in this instar. The sides of the body are pale grass green. The tail is dark brownish on the dorsal and lateral aspects. For biometric data see Table 2.

Third instar larva: This instar is similar to the second instar and differs only in coloration. The sides are pale violet with a shade of ash unlike the second instar. A dark green line borders the lateral limits of the single dorsal fluorescent line. Tail is coloured like in the previous instar, but for its black tip. Head capsule squarish, taller than broad (Fig. 2d). The larva settles under the leaf near the midrib for moulting. The duration of moulting is about 20-24 hours.

Fourth instar larva: This instar is similar in coloration to the previous instars. The single dorsal line is fluorescent yellow green (Fig. 2e). The paradorsal area is bright green and extends to the lateral aspect of the body, which is characterized by a thin pale greenish-white line bordered by a thin dark green shadow. The rest of the lateral surface is white with a pale violet tinge. The head is shaped like the final instar caterpillar.

Final instar larva: The head is triangular and vertex moderately grooved. The head is reticulo-rugose on magnification with short, down curved, long translucent green hair. The neck region and adjoining segments are

Table 2: Biometric data and duration of early stages of *Parantirrhoea marshalli* Wood-Mason 1880 from larvae reared in laboratory conditions (January to July 2006)

Stages	Duration in days	Measurements in centimeters (cm)	Remarks
Egg	Unknown	1.3 mm in diameter & 1.2 mm high	Laid in batches of 2 to 4 on undersides of reed leaf
Newly hatched larva	Unknown	Body: 0.28 - 0.5 cm	Found in twos or threes. Head black, tail bifid.
First instar	4-5 days	Head: <0.1 cm wide Body: 0.5 - 0.8 cm Tail: <0.1 cm	Pairs or triplets. Head: black with a vertical bare area, tail bifid.
Second instar	5-6 days	Head: 0.1 cm wide Body: 0.75 - 1.5 cm Tail: 0.1 cm	Pairs or triplets. Head: pale yellowish green with fluorescent greenish-yellow vertical stripe. Tail bifid.
Third instar	6-7 days	Head: 0.2 cm wide Body: 1.5 - 2 cm Tail: 0.25 - 0.3 cm	Found in pairs and triplets. Tail bifid
Fourth instar	6-7 days	Head: 0.25 cm wide & 0.3 cm high Body: 2 cm - 3.5 cm Tail: 0.4 cm long	Found in pairs. Tail bifid.
Final instar	8-10 days	Head: 0.38 wide & 0.4 cm high. Body: 4.0 cm - 5.8 cm Tail: 0.6 cm long	Found in pairs and singly. Typical features of the larvae appear. Tail almost fused into a single one. Females are larger.
Pupa	10-14 days	1.2 cm - 1.4 cm long 0.75 - 0.85 cm wide 0.4 cm wide at head	The markings on the pupae appeared similar but there was marked individual variation on closer examination. There was a mild variation in shade of the patterns.

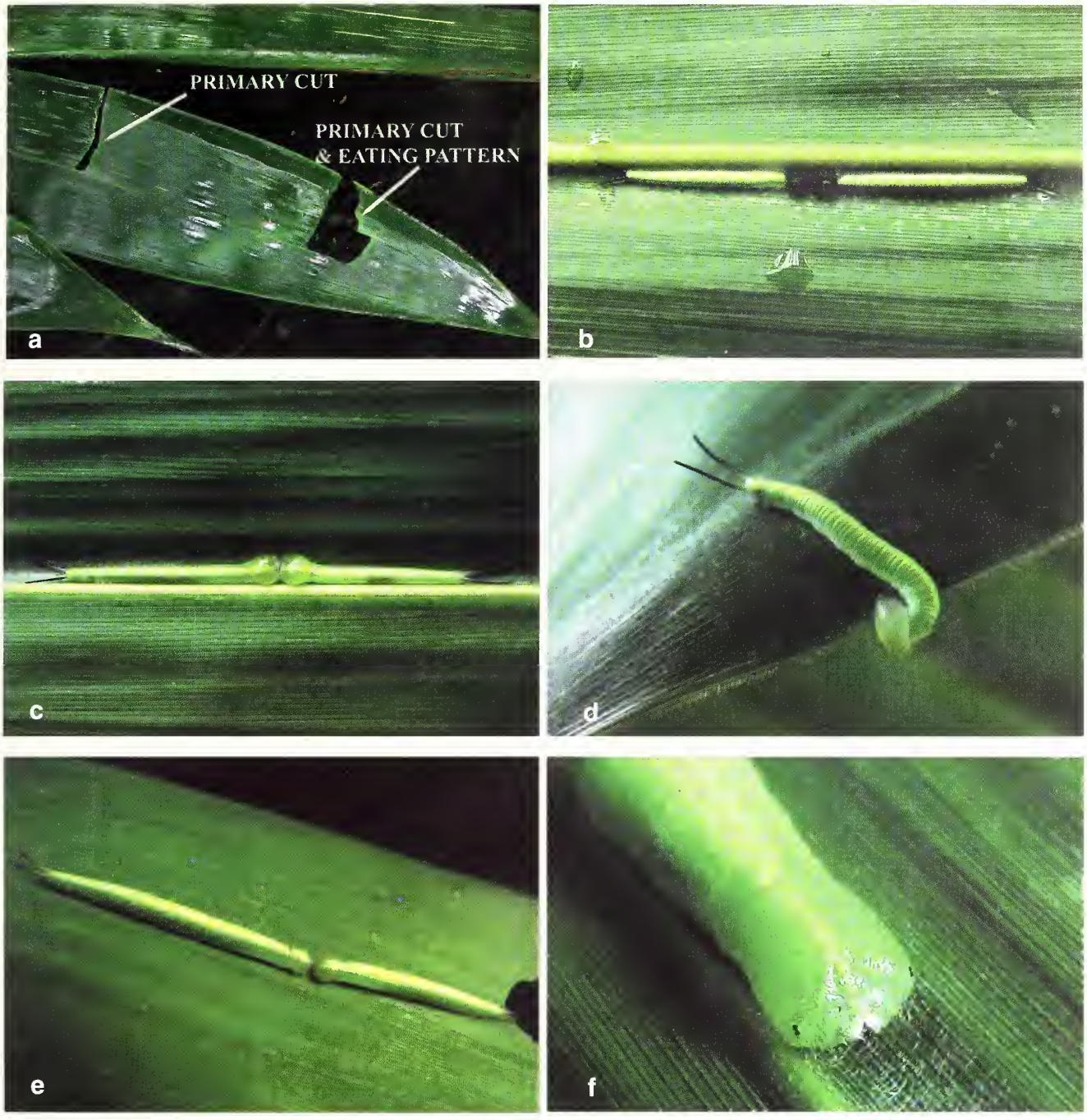

Fig. 2 (a-f): Travancore Evening Brown *Parantirrhoea marshalli*:
a. Characteristic eating pattern of the larva on *Ochlandra travancorica*; b. First instar larva; c. Second instar larva; d. Third instar larva; e. Fourth instar larva; f. Head capsule of the final instar larva

slightly narrow. The body is widest in the middle thirds. On cross-section the body was arched dorsally and the ventrum flat. On lateral view the body was tallest at about the middle then gradually tapered towards the tail. The spindle-shaped body is transversely divided by small annuli. Each segment had five annuli. In each segment proceeding from the head to tail: first the largest annuli, the second an incomplete annulus, and the rest complete annuli. Each annulus ends in a small depression on the last lateral greenish yellow longitudinal line. This is followed by another similar depression in line with the one above. The body has extremely small hairs that are visible only when held against light. The body ends with a tail process. The base of the tail process is wide but tapers rapidly towards its tip. The two tail processes fuse into one in the final instar. However, occasionally the tip of the tail process is bifid. Though finely

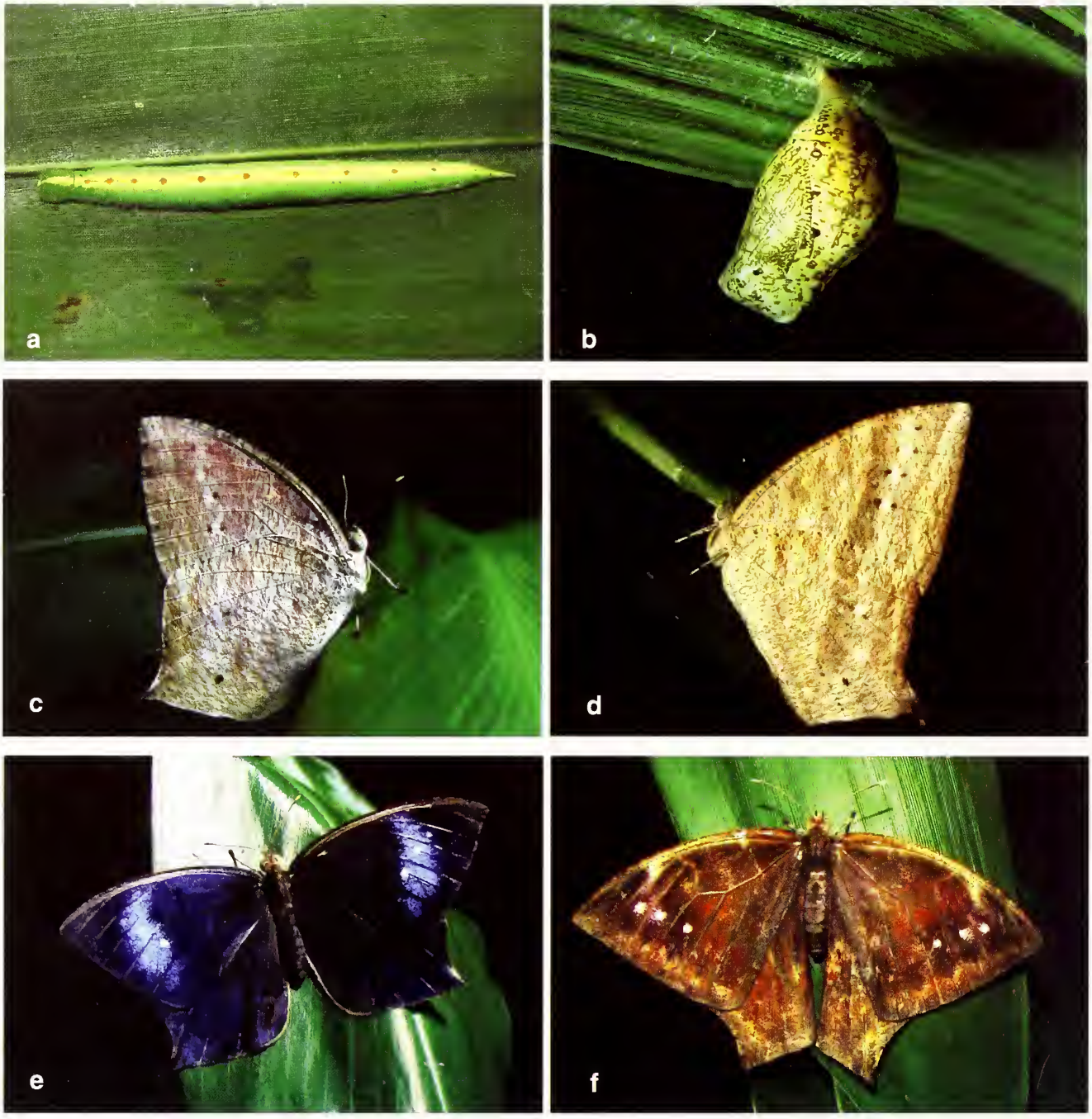

Fig. 3 (a-f): Travancore Evening Brown *Parantirrhoea marshalli*:
a. Final instar larva; b. Pupa; c. Male underside; d. Female underside; e. Male upper side; f. Female upper side

curved, it is held almost parallel to the substratum, except when it is lifted to push out the excrements. The tail process has moderately long hairs on it. The longest hair are on the head followed by tail and then the body. Spiracles are vertically oval and more or less flush with the surface. The male larvae were observed to be shorter and thinner than the female.

The ground colour of the larva is bright green. The larvae have superficial resemblance to the genus *Melanitis* and *Elymnias*. The head is waxy pale greenish yellow with a brownish tinge. It has a bright yellow line that starts from the apex of the clypeus and passes through the vertex into the occiput. The eyes are almost black (Fig. 2f). The body has a pair of fluorescent yellowish green dorsal stripes that start just behind the occiput on the neck and run to the tail plate. In some larvae these lines are almost fused to form a single stripe from the head to tail process. Thus, the dorsal line usually starts from just above the mouth process, runs through the middle of the clypeus to reach its apex and then passes

through the dorsal groove to reach the occipital aspect of head, to continue over rest of the body. Most larvae had an orange line running through the middle of the single dorsal florescent line. There were twelve saffron red spots on this orangish line – a single one at the end of each segment. The last two spots were very pale and obscure (Fig. 3a). Some larvae lacked these spots and the orange line, instead the paradorsal lines were obviously separated by a dorsal-line of green.

There are three faint greenish yellow longitudinal stripes on each side, aligned parallel to the dorsal ones, running from a couple of segments just behind the neck towards the tail. These almost converge and become obscure on reaching the penultimate segment near the tail. A thick lemon yellow to whitish raised line separated the ventrum and lateral aspects. The ventrum was white laterally and translucent in the middle, revealing the ashy or gray inner contents. The tail process is orangish to brownish, except for the proximal area which is greenish, but the tips were invariably black like in previous instars. Tails of caterpillars with a dorsal red line are pale pinkish in the latter half. The larva is bright green and yellow. The sides of the body are ground coloured and infra-spiracular lines are brownish green. The larva rests on the underside of the reed leaf parallel to the midrib, almost always in company of the other larvae. The yellow dorsal line with green sides helps the larvae to camouflage with the yellow of the midrib of the reed leaf. Feeding usually takes place at night. The larvae were also observed to move to distant host plants for feeding.

Pupation: The larva settled under the leaf in open to pupate. Its colour changed to a translucent green then to a dirty waxy yellowish brown and finally to bright translucent pinkish red. The larva hung itself upside down under the leaf with its anal pro-legs. This posture was continued for about 18-20 hours; and it moved only on extreme disturbance. Pupation was completed in about 24 hours.

General shape resembled that of the Common Evening Brown *Melanitis leda* pupa, but it was smaller, compact and more angular (Fig. 3b). The ground colour of the pupa is pale waxy brownish white to rosy brown with dark brown or ash mottling, especially on the wing cases. Dorsally there is an ochreous shade, especially on the rump region in some larvae. Underside is more whitish and glazed. There is a dorsal dark stripe composed of irregular and discontinuous spots or patches, and irregular patterns. The paradorsal region also bears a similar stripe, which is lighter in coloration and is a bit more obscure in the rear thirds. The spiracular stripe is composed of closely disposed vertically oval spiracles whose circumferences were well marked by brown borders. In some spiracles this brown border is deficient in the inferior aspect. All these longitudinal stripes pass backwards, and become obscure and disappear in the following sequence, first the paradorsal, followed by the spiracular and dorsal stripe that continu over to the dorsum of the tail process for some distance. The wing cases are marked by irregular patterns mostly ashy brown that appear running parallel to the venation. There are some ill-defined spots on these lines from which ramifications of brownish shade extend into the surrounding area between the veins. The top of the head is also marked, by irregular triangular design of a darker shade of brown. Undersides, except the wing cases, are paler and almost creamy white. There is a pair of dark spots midway between the eye rudiments and the ends of wing cases. There are three interrupted lines composed of dark brownish spots on the ventrum, two lines in lateral disposition, and last in the exact midline extending towards the tail. The male pupa is sometimes less heavily marked than the female pupa.

Duration of pupal stage was about 10-14 days and the adults (Fig. 3c-f) emerged in the late morning hours and occasionally at noon.

Parasitism and predators: None of the larvae we came across were infested with parasitoid wasps. Larval infections were also not encountered in the field. There have been instances where a recently eaten leaf with all evidences of the larval presence was vacant and the only thing we saw on it was a snail.

CONCLUSION

Information on the early stages of many endemic butterflies of the Western Ghats are still unknown. Some of the recent discoveries are of the larval stages of Golden Flitter *Quedara basiflava* (de Nicéville 1888) by Kunte (2008) and the Sitala Ace *Thoressa sitala* (de Nicéville 1885) by Kalesh and Prakash (under prep.). Observations made in this study have thrown light on the hitherto unknown early stages of the Travancore Evening Brown *Parantirrhoea marshalli* Wood-Mason and have confirmed its larval host plant for the first time. It may be recalled here that Evans (1932) has described the status of *P. marshalli* as rare. In this study it was found that the caterpillars were common during January to July, although the adult butterfly is rarely seen. They are usually seen during cloudy evenings flying amid reed clumps. It was during overcast evenings that adults were seen flying inside reed clumps. At Kallar we could observe only one or two adults after traversing about 5 km. Kunhikrishnan (pers. comm.) reported observing more than 20 adults in a walk of less than 4 km through a considerably large reed plot at Edamalayar-Pooyenkutty valley, along the south-west flanks of the Anamalais in July 2003. We observed that this species is common wherever its larval host plants are available. Adults have been reported to be rare due to their peculiar habits or it

could even be due to considerable larval or pupal mortality under natural conditions.

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A NEW REPORT OF *CEPHRENES ACALLE* HOPFFER (LEPIDOPTERA: HESPERIIDAE) FROM SOUTHERN WESTERN GHATS, WITH NOTES ON ITS NATURAL HISTORY AND IMMATURE STAGES

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The Plain Palm Dart *Cephrenes acalle* Hopffer 1874, which is presently known to occur in India from Bengal to Sikkim, Assam and Andaman & Nicobar Islands, is now recorded for the first time from Thiruvananthapuram in Kerala, peninsular India. This is a significant range extension for this species. A detailed description of the early stages and a note on the natural history of the *C. acalle* is presented. *Cocos nucifera* L. Coconut tree is the host plant for the species in the study area, which enables the species to establish substantial populations. Our observations show that the species is not rare in this region and it was earlier either mistaken for *Telicota ancilla bambusae* Moore or *Telicota colon colon* Fabricius which it resembles, or the species might have eluded early naturalists because of its canopy dependent mode of life. Intensive field surveys in the southern Western Ghats and the Eastern Ghats will help to delineate its exact distributional range and status in peninsular India.

Key words: larval ecology, distributional ranges, range extension, Plain Palmdart, *Cephrenes acalle*, Hesperiidae, Lepidoptera, Western Ghats, Kerala, India

INTRODUCTION

The genus *Cephrenes* is primarily concentrated in the Southeast Asia-Papuan region and Australia with only one species *Cephrenes acalle* Hopffer penetrating into the Indian region. Bell (1910) and Evans (1932) referred to the Indian taxon as *Cephrenes palmarum*, which is, according to Evans (1949), a synonym of *Cephrenes chrysozona oceanica* (Mabille 1904). However, its currently valid taxonomic placement following Corbet *et al.* (1992) is *Cephrenes acalle* Hopffer 1874, and the Indian subspecies is thus *Cephrenes acalle oceanica* (Mabille 1904).

The known distributional range of *Cephrenes acalle* is from West Bengal eastward to Myanmar and parts of Indo-China, and in the Andaman & Nicobar Islands (Bell 1910; Evans 1932). The present report from Thiruvananthapuram, Kerala, India, is a range extension for this species by at least 2,500 km. With this addition the currently known Western Ghats butterfly fauna of 333 species (Kunte 2007) now includes 334 species.

Natural history and field notes on the species

We could not find any published descriptions of the natural history of this species or its early stages. Swinhoe (1913) states that larvae of *Cephrenes* had been reared in Calcutta (now Kolkata) in 1900, but Bell (1910) mentioned that the pictures of the larvae Swinhoe mentioned were never found. Thus, our report is probably the first detailed description of the early stages of *Cephrenes acalle* Hopffer 1874.

Our first sighting of the Plain Palmdart was in December 2006 in the suburbs of Thiruvananthapuram city; a female butterfly was spotted resting on a coconut frond. We photographed the species and confirmed its identity later. Subsequently, four males and four females were seen in the same yard again in December 2006, and in January 2007. Besides collecting samples we observed eight males and four females over a period of two weeks. The fact that all the observed individuals had eclosed recently prompted us to search for caterpillars of the species. Caterpillars were first collected from Thiruvananthapuram in December 2006; some parasitized caterpillars were observed on a coconut tree at Coyalmannam at Palakkad district a few hundred kilometres north of Thiruvananthapuram. Intensive searches at Thiruvananthapuram resulted in the discovery of four caterpillars on a coconut tree 7 m high, from which two male and two female butterflies emerged.

Males of *Cephrenes* look like males of *Telicota*, but the former lacks the characteristic stigma (sex brand) present on the forewings of the latter. Females have narrower, much reduced markings on the upperside and the underside is a dull pinkish-brown rather than orange. Larvae of *Telicota* feed on bamboos and grasses, while *Cephrenes* feeds on palms, including Coconut Palm (Robinson *et al.* 2001). The unusual record by Maxwell-Leffroy and Howlett of *Cephrenes acalle oceanica* feeding on tamarind *Tamarindus indica* (Robinson *et al.* 2001) is probably an error.

Our observations indicate that both the sexes are fond of basking in the sun during mornings, and both visit Coconut Palm flowers exclusively, which were in bloom at the time. As the day advanced, females retired to the undersides or

shaded areas of the coconut fronds, whereas males stayed at vantage points from which they chased other butterflies of their size. Both the sexes were wary but returned back to their former resting places even when disturbed. Flight was extremely powerful and fast, and the species was always found flying high in the canopy. Representative specimens of both the sexes are available in our collection.

METHODOLOGY

The adult butterflies were observed from a fixed point for four hours each in the morning and evening, from 0600 hrs to 1000 hrs, and 1400 hrs to 1800 hrs (Table 1). Adults within a radius of 15 m from this point were included in the analysis; this area included the canopy of eight coconut trees.

The larvae were collected from field and reared under laboratory conditions from January to August 2006. A total of four larvae were reared from first to final instar (Table 1); detailed notes on the larvae, pupae and adult butterflies which emerged were recorded.

The preferred larval host plant was *Cocos nucifera* Coconut palm. It is probable that they feed on other palms too.

Caterpillars collected were reared in plastic containers suitable for their size, for example, a 3 cm long caterpillar was kept in a container 9 cm x 6 cm x 6 cm. Holes of 1mm x 1mm per sq. cm were provided for sufficient aeration and maintaining appropriate humidity. The container was cleaned and fresh leaves were added every day. Measurements were made using Vernier callipers. Morphological descriptions of the larvae follow Bell (1910).

The stage before the first moult has been called newly hatched larva. The area between the sub-dorsal and dorso-lateral aspects of the larvae is described here as the paradorsal region. The adult butterflies reared were released into their natural habitats after photographing them.

Egg

The structure of the egg is not known. It is laid on the under side of the Coconut tree leaflets towards the middle or at the tips as observed on many occasions from remnants of egg shells near the larval cells.

Newly hatched larva

The head capsule is shaped similar to *Telicota* and is shiny black. This stage is characterized by the presence of a chitinous black neck collar on the dorsal half of the neck region. The neck is narrow and the body is widest in the middle, thereafter, it gradually tapers towards the anal end. The body lacks hairs on viewing with naked eyes. The semi-transparent anal plate has a series of long, up-curved and occasionally down curved whitish hairs at its tip. The colour of the body is light honey yellow with a waxy appearance (Fig. 1a).

As soon as the larva emerges from the egg it makes a cell at the tip of the coconut leaflet by joining together the leaf margins with silk strands. This cell is different from other palm feeding Hesperiids like *Suastus*, but resembles that of *Caltoris*. In cases when the egg is laid at the tip of the leaf the larva makes a large cell by joining two overlapping leaflets with silk. The unusually strong silk strands are placed almost equidistant from each other. They feed a little away from the cell, proximally to it on one side of the margin. The eating pattern is characteristic; the larvae start at the leaf margin working almost perpendicular to the long axis reaching the central vein, thereafter, they eat the soft part between the central vein and outer margin leaving the relatively thick margin untouched (Fig. 1b). The approximate duration of moulting phase to the next instar was about 18 to 24 hours. For larval measurements refer Table 2.

First Instar

The head is roughly triangular in shape with the vertex moderately grooved. Body is long, tubular and hairless except

Table 1: Adult butterfly sightings and breeding data of *Cephrenes acalle* Hopffer 1874 (December 2006 to November 2007)

Month and year	Adult sightings N=29 (19 Males,10 females)	Larvae observed N=8 (2 males, 5 females, one undetermined)	Remarks
December 2006	Eight males and five females	One female in 3rd instar	Preyed upon by spider
January 2007	One mating pair and a male	One male	Final instar
February 2007	none	One male	Final instar
March 2007	One male	One 4th instar, unsexed	Parasitized by wasps
April 2007	none	none	none
May 2007	One male	none	none
June 2007	One male	none	none
July 2007	Two males	none	none
Aug 2007	Two males and two females	Newly hatched larva, 2nd,4th, last instar	All successfully reared
September 2007	One female	none	none
October 2007	Two males	none	none
November 2007	One female	none	none

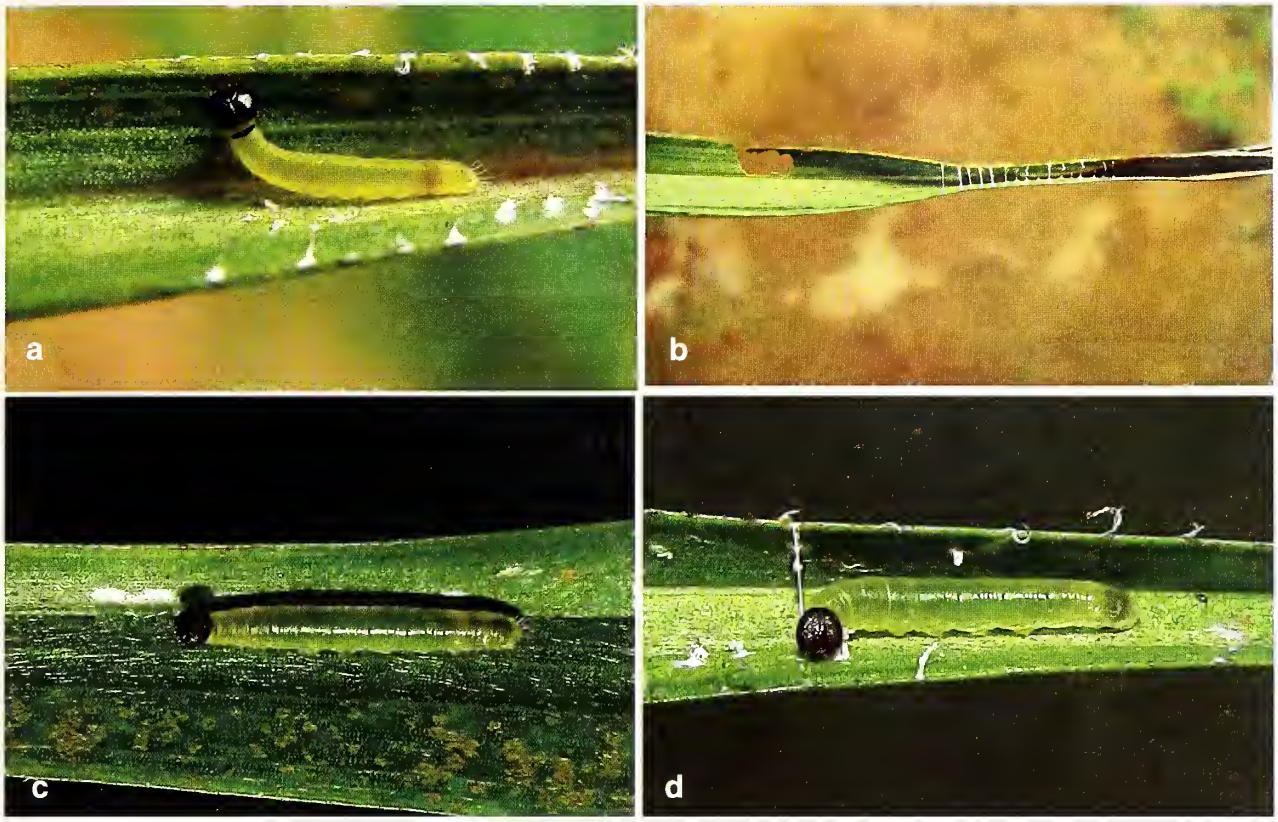

Fig. 1: *Cephrenes acalle* Hopffer 1874 (a-d): a. Newly hatched larva; b. Newly hatched larva cell; c: First instar larva; d. Second instar larva

Fig. 2: *Cephrenes acalle* Hopffer 1874(a-c): a. Third instar larva; b. Fourth instar larva; c. Final instar; d. Larval head

at the tip of the anal plate, which is conspicuous. Head capsule dark brown, body dull sap green (Fig. 1c), skin light honey yellow. The segment just before the anal plate appears greyish because of the internal contents, which are visible through the translucent body. Hairs on the anal plate are translucent.

The cell construction and general behavioural patterns are similar in all the instars. When disturbed they bang the anterior thirds of the body and head on the walls of the cell. The floor of the cell is coated with thick silk. The eating is usually confined to one margin of the distal aspect of the leaflet progressing proximally towards the cell. They sometimes make cells with two leaflets; in which case they usually eat the upper leaflet sparing the lower one, i.e., feeding on the leaflet that forms the floor of the larval cell.

Second Instar

This larva is similar to the first instar larva in colour and structure (Fig. 1d). The duration of larval stages and measurements are given in Table 2.

Third Instar

Head capsule is almost round with a coarse texture on magnification. Vertex is shallow. Neck is narrow. Body is long and cylindrical. Tail plate is semi-circular with a series of long whitish hair on it, especially at the tip. Ground colour of head is pale pinkish-white with a reddish tint. Eyes black. A lateral facial band starts appearing at this stage. It starts as a brownish red band around the eye region and ascends separating the face from the cheeks. Thereafter, the bands on either side meet at the shallow vertex where they become somewhat paler and descend through the vertical groove to reach the apex of the false clypeus where it ends. A single vertical brownish red streak marks the middle of the true clypeus. Mouth parts are brown. The neck and body is pale sap green (Fig. 2a).The semi-transparent skin is pale yellow. The sides of the body are more yellowish and dorsal pulsating line is less delineated in this stage. Tail plate is waxy yellow at the periphery with a grey tinge at the middle. Each segment bears a pair of tiny dark spots in the paradorsal region. Spiracles are vertically oval and are less coloured compared to the later instars.

Fourth Instar

Head capsule is circular in shape. Vertex is shallow. The head is finely reticulo-rugose on magnification. Neck is narrow and thereafter body gradually widens into a cylinder. The later half is dorso-ventrally flattened like in *Baoris*. Anal plate is semicircular in shape and bears a series of long translucent hair at its end.

The ground colour is pale green and skin is pale lemon yellow. The head capsule is waxy brown. The lateral aspect of the lobe face is separated from the cheeks by a dark brown band whose borders are obscure and faded towards the centre of the lobe face. This band passes towards the vertex and then passes down parallel to the vertical groove and to the sides of the false clypeus where it diverges. The main trunk of this band passes onto the level of lower third of true clypeus. The other part passes infero-laterally and gradually fades and merges with the lateral bands. Eyes are black. The dorsal pulsating line is green. Paradorsal band is opaque greenish. The rest of the lateral surface is greenish yellow (Fig. 2b).

Final Instar

The caterpillar looks similar to *Telicota* and *Baoris*. It resembles *Telicota* and *Baoris* in shape while it resembles

Table 2: Biometric data and duration of early stages of *Cephrenes acalle* Hopffer 1874 from larvae reared in laboratory conditions (December 2006-November 2007)

Stages	Duration in days	Measurements in centimeters (cm)	Remarks
Egg	Unknown	Not Available	Laid singly on dorsum of *Cocos nucifera* leaflets usually on well exposed leaves.
Newly hatched larvae	Unknown	Body: length 0.28-0.5 cm	Found in its typical cell at leaflet tip.
1st instar	6 days	Head: width 0.1 cm Body: length 0.7-1.0 cm	Early stages closely resemble that of *Baoris*. Cell near leaf tip, floor of cell smeared with thick mat of strong silk.
2nd instar	5-6 days	Head: width and height 0.12 cm Body: length 0.1-1.75 cm	Similar to the previous instar in all respects.
3rd instar	6-7days	Head: width 0.2 cm Body: length 1.5-3.0 cm	General structure and habits similar to last instar, but testicles more conspicuous. Lobe faces on head capsule pale, lateral bands well-defined. resembles *Polytremis* early stages.
4th instar	6 days	Head: width 0.25 cm; height 0.25 cm Body: length 3.0-3.5 cm	Head capsule richly marked bands may be inconspicuous in this dark background.
Final instar	7-8 days	Head: width 0.3 cm; height 0.4 cm Body: length 3.5-4.5 cm	Typical larva with the characteristic head patterns, more active than predecessors.
Pupa	8-10 days	length 2.5 cm maximum width 0.6 cm width 0.4 cm at head height 0.55 cm at shoulders	Larger than *Telicota* pupa but paler and less richly coloured, Tail processes extremely reduced in contrast to *Telicota*.

Telicota in coloration. Head capsule is vertically oval. Vertex is moderately grooved. On magnification, the head is reticulo-rugose and bears short down-curved translucent hairs. Hair is longest around the mouth parts. Neck region and adjoining segments are the narrowest section of the body. Body is widest in the middle. On cross-section the body is arched dorsally and the ventrum is flat. Body is roughly spindle-shaped and transversely divided by small annuli. On lateral view, the body is highest at about the anterior thirds then gradually tapers and flattens dorso-ventrally towards the anal plate. Each segment has five annuli. In each segment, proceeding in the head to tail direction, the first was the largest annuli, the second annulus is incomplete and the rest were complete annuli. The second annulus has a silver spot in the paradorsal region. This spot is not very clearly appreciated in some segments and is not as conspicuous as in *Baoris*. The body has extremely small hairs, which are visible only when held against light and on simple magnification with a hand lens. The tip of anal plate has the longest hair on it which is visible with the naked eye. Spiracles are vertically oval and more or less flushed with the surface. A dark spot is seen near the antero-superior aspect of the spiracle. Another similar spot is observed postero-inferiorly. The male larvae can be differentiated based on the presence of the paired yellowish orange genital organs, which are visible lying beside the dorsal pulsating line in the later third of the body (Fig. 2c).

The ground colour of the larva is pale greenish. The skin is pale lemon yellow, which is more evident at the skin folds near neck and the paraspiracular regions. The head is waxy pale rose brown. The facial lobes and cheeks are separated by a dark black brown band that begins around the eyes; it then passes through the sides of the lobe, face reaching the vertex. From there the band on each side descends parallel to the vertical groove and gradually widens till it reaches the apex of the false clypeus. Thereafter, the bands taper gradually and do not pass beyond the dorsal half of the true clypeus. Another vertical line of similar colour is observed inside the true clypeus. It starts at the apex of the true clypeus and extends till two thirds of its height. Eyes are almost black (Fig. 2d). The dorsal pulsating line is green. The paradorsal bands are opaque, pale white green. The spiracles are lemon yellow in colour.

The cell is made by joining together the two ends of the leaflet making a flattened cell at the leaf tip. Then it eats from the leaf tip advancing proximally leaving the central woody vein. Feeding usually takes place in the dark hours, but they will feed even during the daytime if not disturbed.

Pupation

The larva settles inside the last residing cell for pupation. Its colour changes to yellowish white. The whole cell is smeared with whitish cereous excretion, which serves as protection against moisture and rain. The amount of this cereous secretion is more than that observed in *Telicota* pupae. The larvae lie motionless and this posture is continued for about 24 hours; the whole process of pupation is completed within this time.

The general structure resembles that of the *Telicota* and *Thoressa-Halpe* group. The pupa is larger in dimensions, but paler in coloration in comparison with *Telicota*. There are no body bands or any cremasteric adhesions (Fig. 3a).

On dorsal view the head is finely curved on front. The snout is absent but the region is marked with a single dark spot. There are some tufts of long hairs around the snout and eyes. The stigma present postero-superior to the eyes is reniform in shape. The body is widest at the origin of wings. Thereafter, the width is constant till about the last quarter, but tapers off rapidly to end in the highly rudimentary tail process. On lateral view the highest point is the hump of the thorax, which is convex; this is followed by a moderate abdomino-thoracic constriction (Fig. 3b). The rest of the body is of a smoother convex contour, which rapidly tapers off from the rear thirds to end in the tail process. On the ventral view, the proboscis is much longer than the rest of *Telicota* and extends to surpass more than half of the second segment distal to the wing cases. It extends for 2 mm when measured from the tips of wing cases (Fig. 3c). In contrast to *Cephrenes*, both species of *Telicota* have short proboscis and it never extends beyond the first intersegmental space distal to the wing cases. The tail process is a short and straight extension from the rear, these are irregular and much reduced in comparison to *Telicota* (Fig. 3d). In *Telicota* the tail process is almost a trapezoid one with a terminal series of uniformly long down-curved hooklets. The whole body is clothed in evenly distributed sparse, moderately long, reddish brown hairs which are more numerous near the rear and front segments.

The general colour of the pupa is pale yellowish white while in contrast the pupae of *Telicota* are much more deeply coloured in brownish yellow with an orangish tint. Head is waxy brownish yellow. The stigma on either sides of the eye rudiments are dark brown. Thorax is coloured pale waxy honey yellow with a greenish tinge. Abdomen is whitish yellow. The spiracles are translucent pale brownish. The tail processes are reddish brown. Duration of pupal stage is about 10 days. The adult butterflies usually (Fig. 4) emerge in the morning hours.

Parasitism and predators

One of the larvae was found to be infesting with parasitoid wasps. Larval infections are rare. Jumping spiders were observed as predators of larvae and adults in the field. Adults also fall prey to Red ants *Oecophylla smaragdina*.

Fig. 3: *Cephrenes acalle* Hopffer 1874(a-d): a. Pupa dorsum; b. Pupa lateral view; c. Pupa ventrum; d. Tail

Fig. 4: *Cephrenes acalle* Hopffer 1874(a-d): a. Male underside; b. Female underside; c. Male upperside; d. Female

CONCLUSION

We have presented here the first detailed descriptions of the early stages of the *Cephrenes acalle* Hopffer, and reported for the first time the presence of the species in southern India. In this study, it was found that adults were not uncommon in southern Kerala where its larval host plant is available, but was described rare owing to its peculiar habit of keeping to high canopies of coconut trees. Previous works (Fergusson 1891; Kunhikrishnan 2002) on Lepidopteran fauna focussed on this region of the peninsula might have overlooked this species for the related *Telicota* genus. Only larval rearing and detailed adult examination would have revealed the differences between them, moreover these works mainly concentrated on the higher elevations of the Western Ghats and the forested interiors of the district where Coconut, the preferred host plant, is relatively uncommon. Intensive surveys in the northern and central Western Ghats and in the Eastern Ghats will help to delineate its current distributional range and status in peninsular India. Taxonomical and genetic analysis has to be undertaken to confirm the subspecies status of this species.

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FAUNAL DIVERSITY OF CLADOCERA (CRUSTACEA: BRANCHIOPODA) OF LOKTAK LAKE (A RAMSAR SITE), MANIPUR (N.E. INDIA)

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Plankton samples collected from Loktak lake (a Ramsar site) during November 2002-October 2004 revealed 51 species of Cladocera belonging to 28 genera and 7 families. Loktak lake holds the richest Cladocera biodiversity known from any individual aquatic ecosystem of India, so far. The cladoceran fauna is characterized by predominance of Chydoridae > Daphniidae, Cosmopolitan > Cosmotropical species, general tropical character, dominance of littoral-periphytic taxa and lack of seasonal periodicity of occurrence of different families or species. Richness varies between 22-42 (29 ±5) and 20-41 (28 ±5) species and, records 51.7-82.33% and 53.6-90.0% community similarities (*vide* Sorenson's index) during two years respectively. It exhibits identical trimodal annual patterns with maxima during winter and minima during monsoon. ANOVA registers significant temporal variations in richness of Cladocera between months and insignificant between years. Richness is inversely correlated with water temperature, rainfall, pH, hardness, nitrate, chloride and total dissolved solids, and is positively correlated with dissolved oxygen. Multiple regression analysis indicates moderately higher cumulative influence of fifteen abiotic factors on richness.

Key words: Ramsar site, Loktak lake, Cladocera, biodiversity, distribution, temporal variations

INTRODUCTION

Cladocera, an important group of fish-food, and an integral component of meta-zooplankton, have been reported from scattered localities from different states of India since 1860s. There is, however, limited information on their diversity in different aquatic ecosystems, particularly flood plains, of India (Sharma and Sharma 2008a). Investigations on Cladocera diversity of 'Ramsar sites' of India are so far restricted to Deepor beel (Sharma and Sharma 2008b, 2009), one of the largest floodplain wetlands of Assam (N.E. India), and wetlands of Keoladeo National Park, Rajasthan (Venkataraman 1992).

Loktak Lake, a Ramsar site, and one of the largest natural freshwater lakes of eastern India, is under severe environmental stress because of serious habitat degradation, influx of waste water, and encroachment of land for agriculture and human settlements. Attempts are being undertaken to manage this biologically, environmentally and socio-economically important floodplain wetland of South Asia. Little is known about the micro-faunal diversity of Loktak lake in general, and that of Cladocera in particular; the information on the later is limited to a preliminary unpublished list of Shyamananda Singh (1991).

The present study, the first detailed systematic account of Cladocera of Loktak lake, is therefore significant. Observations were made to determine species composition, temporal variations in richness, and community similarities of these micro-crustaceans. The nature and composition of the cladoceran taxocoenosis are discussed. Remarks are made on occurrence and distribution of various interesting elements and on influence of the abiotic factors on Cladocera richness.

MATERIAL AND METHODS

The present study forms a part of a limnological survey of Loktak lake, Bishnupur / Imphal districts, Manipur, undertaken from November 2002-October 2004 (24° 25'-24° 42'N; 93°46'-93°55'E; area: 286 sq. km; max. depth: 4.58 m; altitude: 768.5 m above msl). This floodplain wetland is characterized by floating mats of vegetation called *Phumdi*, which are inhabited by the endangered Brow-antlered Deer (*Cervus eldii eldii*). The common aquatic plants of this lake include *Eichhornia crassipes*, *Hydrilla verticellata*, *Euryale ferox*, *Vallisneria spiralis*, *Utricularia flexuosa*, *Trapa natans*, *Lemna trisula*, *Pistia striates*, *Salvinia* sp., *Nymphaea* spp., *Nymphoides* spp., *Nelumbo mucifera*, *Potamogeton* spp. and *Azolla pinnata*.

Plankton samples were collected seasonally from different parts of Loktak basin (during November 2002-October 2004) by towing a nylobolt plankton net (mesh size: 50 µm). In addition, water and plankton samples were collected regularly every month, during the study period at Sendra (24° 30'56.75" N; 93°47'45.61" E). All the plankton samples were preserved in 5% formalin.

Water samples were analyzed for various abiotic factors following standard methods (APHA 1992), while water temperature, specific conductivity, pH, and dissolved oxygen

were recorded with field probes. Qualitative plankton samples were screened; Cladocera species were isolated and were identified following the works of Smirnov (1971, 1976, 1992, 1996), Michael and Sharma (1988), Korovchinsky (1992), Sharma and Sharma (1999, 2008a) and Orlova-Bienkowskaja (2001).

Percentage similarities between monthly cladoceran communities were calculated *vide* Sorenson's index and were analyzed by hierarchical cluster analysis (SPSS version 10). The significance of temporal variations of richness was ascertained *vide* ANOVA. Ecological importance of individual abiotic factors was studied *vide* simple correlation coefficients (r). Multiple regression analysis was undertaken to analyze cumulative influence of fifteen abiotic factors, namely water temperature, rainfall, pH, conductivity, dissolved oxygen, free CO_2, alkalinity, hardness, nitrate, phosphate, sulphate, silicate, chloride, dissolved organic matter and total dissolved solids.

RESULTS AND DISCUSSION

Abiotic parameters

Mean water temperature affirms sub-tropical range of Loktak lake. Specific conductivity indicates low ionic concentrations (Table 1) and warrants inclusion of this Ramsar site under 'Class I' category of 'trophic classification' of Talling and Talling (1965). Slightly acidic and soft waters of this floodplain wetland depict moderate dissolved oxygen, low free CO_2, low concentration of micronutrients and other abiotic factors (Table 1).

Table 1: Abiotic factors of Loktak lake

Parameters	Range	Mean ± SD
Water Temp. (ºC)	14.2-28.5	21.8 ±4.2
Rainfall (mm)	0.0-480.0	138.2 ±154.8
pH	5.70-6.92	6.31 ±0.32
Sp. Cond. (µS/cm)	66.0-132.0	93.3 ±17.1
Dissolved Oxygen (mg/l)	4.2-9.0	5.7 ±1.1
Free CO_2 (mg/l)	6.0-13.0	9.2 ±2.0
Alkalinity (mg/l)	10.0-41.2	19.1 ±7.1
Hardness (mg/l)	24.0-54.0	38.3 ±7.8
Calcium (mg/l)	5.4-15.7	9.8 ±2.7
Magnesium (mg/l)	2.0-8.6	5.4 ±1.9
Sodium (mg/l)	0.6-7.5	4.8 ±2.0
Potassium (mg/l)	2.0-9.2	5.9 ±1.0
Phosphate (mg/l)	0.12-0.32	0.22 ±0.10
Nitrate (mg/l)	0.25-0.42	0.32 ±0.04
Sulphate (mg/l)	0.54-0.99	0.86 ±0.12
Silica (mg/l)	7.42-12.70	10.1 ±1.4
Chloride (mg/l)	10.0-20.1	15.8 ±3.0
DOM (mg/l)	0.7-2.1	1.34 ±0.39
TDS (mg/l)	0.16-0.81	0.44 ±0.19

Cladocera composition and distribution

51 species of Cladocera belonging to 28 genera and 7 families, examined from Loktak lake (Table 2) reflect a rich biodiversity of this group known from a floodplain lake, or aquatic ecosystem of the Indian subcontinent. The rich faunal diversity indicates greater environmental heterogeneity of this Ramsar site and re-affirms recent remarks (Sharma 2009) on the biodiversity of Rotifera of this wetland. The recorded species comprise about 40.9% of the Indian freshwater Cladocera. The present report also assumes special importance in view of a conservative estimate of occurrence of up to 60-65 Cladocera species in tropical and subtropical environs of India (Sharma and Michael 1987; Sharma 1991). Our results, however, present a distinct contrast to only 12 species listed earlier from Loktak (Shyamananda Singh 1991).

The richness of Cladocera recorded at Loktak is higher than that reported from Deepor beel (45 species) (Sharma and Sharma 2008b). The generic diversity at Loktak is marginally lower than that of Deepor (30 genera), while species composition of these two Ramsar sites indicate 75% similarity (*vide* Sorenson index), indicating occurrence of several common species. The richness at Loktak is higher than the 30 species reported from 30 wetlands of Keoladeo National Park (Venkataraman 1992), 36 species from 20 wetlands of South-eastern West Bengal (Khan 2003), 11 species from 2 floodplain lakes (Khan 1987) of Kashmir, 9 species from 65 wetlands of 24-Parganas district (Nandi *et al.* 1993) of West Bengal, 12 species (Sanjer and Sharma 1995) from floodplains of Bihar, and 14 species from 37 floodplain lakes (Sarma 2000) of Assam.

Of the biogeographically interesting species recorded from Loktak was *Disperalona caudata* – an Australasian species earlier known to occur only in Thailand and Australia; it was recently reported from India from Deepor beel (Sharma and Sharma 2007). *Simocephalus acutirostratus* may also be assigned as an Australasian species as it is known with certainty only from Australia and South-East Asia (Orlova-Bienkowskaja 2001). *S. heilongjiangensis*, another interesting species, has been often confused with its geographical vicariant *S. latirostris*; this generalization is also true for all earlier Indian reports, including those of Michael and Sharma (1988). The erroneous identification of *S. mixtus* with its geographical vicariant *S. vetulus* holds parallel with the earlier example both in taxonomic status as well as its earlier Indian reports. *S. vetulus* was previously assumed to be a cosmopolitan species, but the monographic revision of genus *Simocephalus* (Orlova-Bienkowskaja 2001) reveals its European and North African distribution, while *S. mixtus* is distributed in Asia, Eastern Europe, North Africa and North America (Yoon and Kim 2000). Amongst other interesting

species, *Diaphanosoma senegal* is a Palaeotropical species, *Sida crystallina* and *Picripleuroxus laevis* are notable Palaearctic elements, while *Camptocercus uncinatus* is an interesting recent addition (Sharma 2008) to the Indian Cladocera. In addition, *Alonella clathratula*, *Alona davidi*, *A. globulosa*, *A. guttata*, *Ceriodaphnia laticaudata*, *Chydorus faviformis*, *C. ventricosus*, *Dadaya macrops*, *Guernella raphaelis*, *Kurzia longirostris*, *Macrothrix odiosa* and *Pseudochydorus globosus* are examples of regional distributional interest.

The cladoceran taxocoenosis of Loktak lake depicts general tropical character with greater richness of Cosmopolitan > Cosmotropical species, and presence of several Circumtropical and Pantropical species. These salient features are further endorsed by occurrence of the Circumtropical genera *Dadaya* and *Guernella* and, the Pantropical *Ephemeroporus* though a number of the remaining genera are known for their cosmopolitan or worldwide distribution (Dumont and Negrea 2002). The cladoceran communities are characterized by dominance of littoral-periphytonic species, particularly of the families Chydoridae, Macrothricidae, Sididae and Ilyocryptidae. Our collections, however, exhibit fewer limnetic taxa belonging to Daphniidae, Bosminidae and Moinidae. The dubious listing of three species of *Daphnia* by Shyamananda Singh (1991) is misleading and warrants confirmation, as the euplanktonic genus *Daphnia* is known for its restricted distribution, as well as paucity of species in N.E. India (Sharma 1991).

Cladocera richness

Cladocera comprise the second most important group of zooplankton of Loktak contributing significantly in

Table 2: Systematic list of Cladocera from Loktak lake

Phylum : **Arthropoda**
Super-class : **Crustacea**
Class : **Branchiopoda**
Super-order : **Cladocera (*s. str.*)**

Order: **Ctenopoda**
Family: **Sididae**
Diaphanosoma excisum Sars, 1885
D. sarsi Richard, 1895
D. senegal Gauthier, 1951
Pseudosida bidentata Herrick, 1884
Sida crystallina (O.F. Müller, 1776)

Order: **Anomopoda**
Family: **Daphniidae**
Ceriodaphnia cornuta Sars, 1885
C. laticaudata P.E. Müller, 1867
Scapholeberis kingi Sars, 1901
Simocephalus (*Echinocaudus*) *acutirostratus* (King, 1853)
S. (*Coronocephalus*) *serrulatus* (Koch, 1841)
S. (*Simocephalus*) *mixtus* Sars, 1903
S. (*Simocephalus*) *vetuloides* Sars, 1898
S. (*Aquipiculus*) *heilongjiangensis* Shi & Shi, 1994

Family: **Bosminidae**
Bosmina longirostris (O.F. Müller, 1776)
Bosminopsis deitersi Richard, 1895

Family: **Moinidae**
Moina micrura Kurz, 1874

Family: **Macrothricidae**
Guernella raphaelis Richard, 1892
Macrothrix laticornis (Fischer, 1857)
M. odiosa (Gurney, 1907)
M. spinosa King, 1853
M. triselialis (Brady, 1886)

Family: **Ilyocryptidae**
Ilyocryptus spinifer Herrick, 1882

Family: **Chydoridae**
Subfamily: **Chydorinae**
Alonella clathratula Sars, 1886
A. excisa (Fischer, 1854)
Chydorus faviformis Birge, 1893
C. sphaericus (O.F. Müller, 1776)
C. ventricosus Daday, 1898
Dadaya macrops (Daday, 1898)
Disperalona caudata Smirnov, 1996
Dunhevedia crassa King, 1853
Ephemeroporus barroisi (Richard, 1894)
Picripleuroxus laevis Sars, 1862
P. similis Vavra, 1900
Pseudochydorus globosus (Baird, 1843)

Subfamily: **Aloninae**
Acroperus harpae (Baird, 1834)
Alona affinis (Leydig, 1860)
A. costata Sars, 1862
A. davidi Richard, 1895
A. globulosa (Daday, 1898)
A. guttata Sars, 1862
A. intermedia (Sars, 1862)
A. monacantha Sars, 1901
A. quadrangularis (O.F. Müller, 1776)
A. rectangula Sars, 1862
A. verrucosa (Sars, 1901)
Euryalona orientalis (Daday, 1898)
Camptocercus uncinatus Smirnov, 1973
Karualona karua (King, 1853)
Kurzia longirostris (Daday, 1898)
Leydigia acanthocercoides (Fischer, 1854)
Oxyurella singalensis (Daday, 1898)

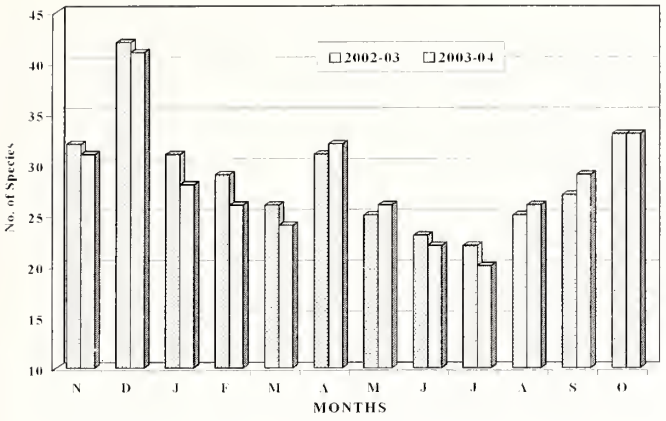

Fig. 1: Temporal variations in Species richness of Cladocera

richness (r = 0.877) and, hence, concur with their composition in beels of the Brahmaputra river basin (Sharma and Sharma 2008a,b). All the 51 species recorded from Loktak were observed in the samples collected during the first year, while only 47 species were recorded in the following year. Monthly richness (22-42, 29 ±5; 20-41, 28 ±5 species) exhibits identical annual ranges and mean values, and follows identical trimodal annual patterns (Fig. 1) with maxima during winter and minima during monsoon; the former aspect is affirmed by an inverse correlation between richness and water temperature (r = -0.512). Further, winter annual peaks of Loktak Cladocera correspond with those of Deepor beel (Sharma and Sharma 2008b) while monsoon minima differ from summer minima of the Deepor beel. ANOVA registers significant temporal variations in richness between months ($F_{11, 23}$ = 10.371, $p < 0.005$), but records insignificant annual variations. Richness records significant inverse correlations with rainfall (r = -0.562), pH (r = -0.504), hardness (r = -0.658), nitrate (r = -0.564), chloride (r = -0.627), and total dissolved solids (r = -0.785), and is positively correlated with dissolved oxygen (r = 0.443). Multiple regression registers moderately higher cumulative influence of 15 abiotic factors (R^2 = 0.703) on Cladocera richness while step-wise regression re-affirms importance of rainfall, pH, hardness, nitrate, chloride and total dissolved solids.

The Chydoridae, the most diverse family of Cladocera, contributes dominantly (29 species, 16 genera) to the faunal diversity in Loktak and broadly concurs with the qualitative role observed in Deepor beel (Sharma and Sharma 2008b). The chydorid richness varies between 13-21 and 12-23 species

Table 3: Percentage similarities (Sorenson's index) of Cladocera (2002-03)

Months	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct
Nov	-	78.3	73.0	65.6	65.5	66.7	66.7	69.1	74.1	70.1	64.4	76.9
Dec		-	78.9	67.6	67.6	74.0	65.7	58.5	59.4	65.7	72.5	74.7
Jan			-	80.0	70.2	67.7	67.8	66.7	64.1	66.7	65.5	75.0
Feb				-	76.4	70.0	70.4	61.5	62.7	74.1	71.4	70.1
March					-	65.5	58.8	53.1	62.5	82.3	71.7	70.1
April						-	64.3	66.7	52.8	67.8	68.9	75.7
May							-	55.2	59.6	68.0	73.1	68.9
June								-	54.5	51.7	64.0	71.4
July									-	68.1	53.0	65.1
Aug										-	73.1	75.0
Sept											-	70.0
Oct												-

Table 4: Percentage similarities (Sorenson's index) of Cladocera (2003-04)

Months	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct
Nov	-	75.0	78.0	80.7	80.0	88.7	73.4	71.7	70.6	80.7	90.0	71.9
Dec		-	69.5	62.3	64.6	76.7	68.6	63.5	62.3	68.6	77.7	81.8
Jan			-	70.3	65.4	73.3	70.4	76.0	83.3	70.2	80.7	72.1
Feb				-	72.0	79.3	69.2	70.8	69.5	76.9	80.0	77.9
March					-	78.6	80.0	53.6	72.7	80.0	79.2	77.2
April						-	72.4	74.1	65.4	79.3	81.9	76.9
May							-	66.7	73.9	80.8	80.0	71.1
June								-	80.9	62.5	66.7	69.1
July									-	78.2	75.5	71.7
Aug										-	80.0	77.9
Sept											-	77.4
Oct												-

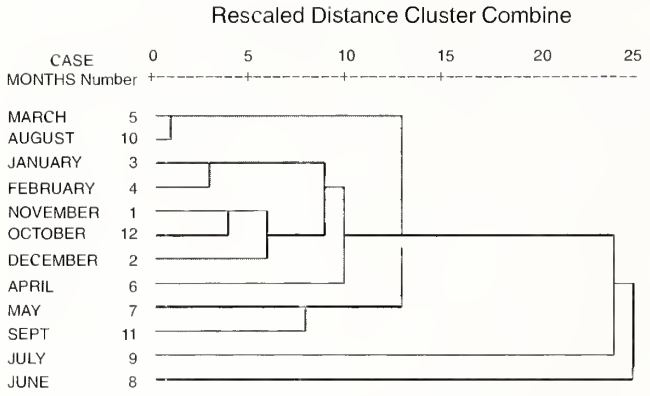

Fig. 2: Dendrogram showing Hierarchical cluster analysis of Cladocera (2002-03)

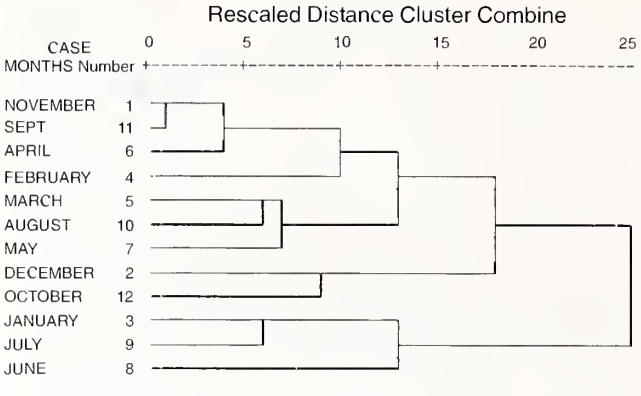

Fig. 3: Dendrogram showing Hierarchical cluster analysis of Cladocera (2003-04)

in two years respectively, follows trimodal annual patterns of monthly richness and show lack of any seasonal periodicity. The Chydorids register significant temporal variations between months ($F_{11, 23} = 11.944$, $p < 0.005$) and insignificant between years. They register significant inverse correlations with rainfall (r = -0.423), hardness (r = -0.499), chloride (r = -0.433), and total dissolved solids (r = -0.664) while multiple regression registers moderate cumulative influence of 15 abiotic factors ($R^2 = 0.573$) in their richness.

Cladocera community similarities

The cladoceran communities indicate (Tables 2 and 3) similarities (*vide* Sorenson's index) ranging between 51.7-82.3% during first year of the study period and a marginally higher range (53.6-90.0%) in the following year. The ranges broadly concur with the reports of Sharma and Sharma (2008a,b) in the floodplain lakes of Brahmaputra river basin of Assam state. A majority of instances (47.0%) in the matrix, however, indicate similarities between 60-70% during 2002-03, while it ranges between 70-80% in majority of instances (60.6%) during 2003-04. Higher similarity values may be attributed to more perennial or nearly perennial species, and fewer rare species occurring in limited monthly samples during each year. The cluster analysis (Figs 2 and 3) exhibits variations in faunal composition of Cladocera during both the years. Our results show (Fig. 2) more closeness of cladoceran communities between March and August, and again between January and February while June and July collections indicate greater differences in their composition during the first year (November 2002-October 2003). In the succeeding year (November 2003-October 2004), greater closeness (Fig. 3) is noticed between November and September (peak similarity), while the samples collected during December and June indicate greater differences in their species composition.

To sum up, the Cladocera of Loktak are characterized by varied taxocoenosis, occurrence of various species of global or regional distributional importance, significant monthly variations of richness, qualitative dominance of littoral-periphytonic taxa, and paucity of euplanktonic species. The results show lack of seasonal periodicity of occurrence of a number of species belonging to different families as well as of individual species. Various abiotic factors exert limited influence individually on Cladocera richness. On the other hand, higher cumulative influence is observed as a number of these factors are also interdependent.

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OPISTHOBRANCH FAUNA OF LAKSHADWEEP ISLANDS, INDIA, WITH 52 NEW RECORDS TO LAKSHADWEEP AND 40 NEW RECORDS TO INDIA: PART 1

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Opisthobranchs are the least studied fauna of India. The present study was carried out in Lakshadweep Archipelago between 2005 and 2009. During the 4-year study a total of 60 species from 25 families were recorded. Of these 60 species, 52 are new records to Lakshadweep and 40 are new records to the Indian coast.

Key words: Opisthobranchs, Lakshadweep, Aeolid, Dorid

INTRODUCTION

Nudibranchs belong to Phylum Mollusca, Class Gastropoda and Subclass Opisthobranchia. These are among the least studied molluscs in India. The work done on Opisthobranchs in India is little and patchy, and the earlier works date back to 1880s by Alder and Hancock (1864), Kelaart (1858, 1859, 1883) and Gardiner (1903). The earliest work on Opisthobranchs in Lakshadweep was by Gardiner (1903). Subsequently, Eliot (1903, 1906, 1909, 1910a, 1910b, 1916), Farran (1905), Hornell (1909), O'Donoghue (1932), Rao (1936, 1952, 1961), Winckworth (1946), Satyamurthi (1952), Gideon *et al.* (1957), Rao and Alagarswami (1960), Narayanan (1968, 1970), Burn (1970), Rao *et al.* (1974), Valdés *et al.* (1999), and Valdés (2002) worked on the Opisthobranchs from the Indian coast. Recent work on this group is limited. Fontana *et al.* (2001) studied the bioactive substances in Indian nudibranchs. Rudman (1970, 1971, 1980, 1984, 1986, 1990), Yonow (1984a,b, 1986, 1988, 1994, 1996), Gosliner and Willan (1991), Gosliner (1992, 1994, 1995), Gosliner and Behrens (1998), Gosliner and Johnson (1999), Gosliner *et al.* (1996), and Brunckhorst (1993) reviewed the status of various Opisthobranch groups in the Indo-Pacific region.

STUDY AREA

The present study was carried out in the Lakshadweep Archipelago. The smallest Union Territory of India, Lakshadweep is an archipelago of twelve atolls, three reefs and five submerged banks. Of the 36 islands spread across 32 sq. km, each ranging from 0.1 to 4.9 sq. km, only 11 are inhabited. The islands lie scattered in the Arabian Sea about 225-445 km from the Kerala coast. They have a distinct lagoon on the west, whereas the eastern side lacks a lagoon. The depth of the lagoon varies from island to island. The maximum depth in smaller lagoons, such as Kavaratti, Chetlat, Kiltan, Kalpeni, Amini, and Kadmat, is usually up to 4 m. However, in larger lagoons, such as Suheli, Bitra, Bangaram and Minicoy, it is up to 10 m. The study was conducted from October to April from 2005-2009, each year, at Kavaratti, Agatti, Minicoy, Suheli, Chetlat, Bangaram, Bitra, Kiltan, Kalpeni and Kadmat islands.

METHODOLOGY

Direct search method was used to collect specimens: Detailed notes on behavioural observations were made.

Preservation of specimen: Specimens were stored in ethyl alcohol after studying the morphological characters. Live specimens of each species were photographed for recording true colours. Barring a few specimens, majority of the specimens are available with the author and will be deposited in the BNHS collections.

RESULTS AND DISCUSSION

During the 4-year study a total of 60 species were recorded belonging to 25 families. Of these 60 species, 52 are new records to Lakshadweep. Of these 52 species, 40 are new records to the Indian coast (Table 1). This clearly indicates that Opisthobranchs in India are least studied. Most Opisthobranch species possess bioactive molecules and tremendous potential in medical science; it is therefore essential to undertake extensive taxonomic study of this group.

Description of species recorded in Lakshadweep

Family: **Hydatinidae**

***Hydatina velum* (Lightfoot, 1786)** (Fig. 1a)

India: Widely distributed both on east and west coast of India.

Extralimital Distribution: Indo-Pacific.

Size: 30 mm.

Description: This is a benthic species. The shell of the species is light and semi-transparent. Centre of body whorl bears one distinct pair of dark brown band. A single brown band present near the spire and at the base of the body whorl.

Table 1: Opisthobranch fauna of Lakshadweep

Family	Species	New Record to Lakshadweep	New Record to India
Hydatinidae	*Hydatina velum*	-	-
Bullinidae	*Bulla ampulla*	-	-
Haminaeidae	*Haminoea cymbalum*	✓	-
Aglajidae	*Chelidonura electra*	✓	✓
	Chelidonura punctata	✓	✓
Gastropteridae	*Sagaminopteron psychedelicum*	✓	✓
Aplysiidae	*Aplysia dactylomela*	-	-
	Aplysia parvula	✓	✓
	Dolabella auricularia	✓	✓
	Dolabrifera dolabrifera	✓	✓
	Stylocheilus striatus	✓	✓
Pleurobranchidae	*Pleurobranchus peroni*	✓	✓
	Pleurobanchus albiguttatus	✓	✓
	Berthellina cf *delicata*	✓	✓
	Euselenops luniceps	✓	-
Smaragdinellidae	*Phanerophthalmus smaragdinus*	✓	✓
Polybranchiidae	*Polybranchia orientalis*	✓	-
Volvatellidae	*Volvatella vigourouxi*	✓	✓
Elysiidae	*Elysia ornata*	✓	-
	Elysia tomentosa	✓	-
	Thuridilla carlsoni	✓	✓
	Thuridilla gracilis	✓	-
	Thuridilla livida	✓	✓
	Thuridilla vatae	✓	✓
	Plakobranchus ocellatus	✓	-
Notodoridídae	*Aegires* sp.	✓	✓
Gymnodorididae	*Gymnodoris* sp.	✓	✓
	Gymnodoris ceylonica	✓	-
	Gymnodoris alba	✓	✓
Chromodorididae	*Chromodoris* cf *setoensis*	✓	✓
	Chromodoris fidelis	✓	✓
	Glossodoris cincta	✓	✓
	Hypselodoris maculosa	✓	✓
	Hypselodoris infucata	✓	-
	Hypselodoris maridadilus	✓	✓
Discodorididae	*Peltodoris murrea*	✓	✓
Kentrodorididae	*Jorunna rubescens*	-	-
	Jorunna funebris	✓	-
Platydorididae	*Platydoris cruenta*	✓	✓
Doridídae	*Halgerda tessellata*	✓	✓
	Asteronotus cespitosus	✓	-
Phyllidiidae	*Phyllidia coelestis*	✓	✓
	Phyllidia vericosa	✓	✓
	Phyllidia alyta	✓	✓
	Phyllidia marindica	✓	✓
	Phyllidiella pustulosa	-	-
	Phyllidiella rosans	-	-
	Phyllidiella zeylanica	-	-
	Phyllidiopsis phiphiensis	✓	✓
	Phyllidiopsis striata	✓	✓
	Phyllidiopsis gemmata	✓	✓
Dendrodorididae	*Dendrodoris tuberculosa*	✓	-
	Dendrodoris nigra	-	-
Actinocyclidae	*Actinocyclus verrucosus*	✓	✓
Tritoniidae	*Marianina rosea*	✓	✓
Flabellinidae	*Flabellina bicolor*	✓	✓
Tergipedidae	*Phestilla lugubris*	✓	✓
Facelinidae	*Pteraeolidia ianthina*	✓	✓
	Herviella affinis	✓	✓
	Herviella albida	✓	✓
25 families	60 species	52	40

'✓': new record; '-': earlier record

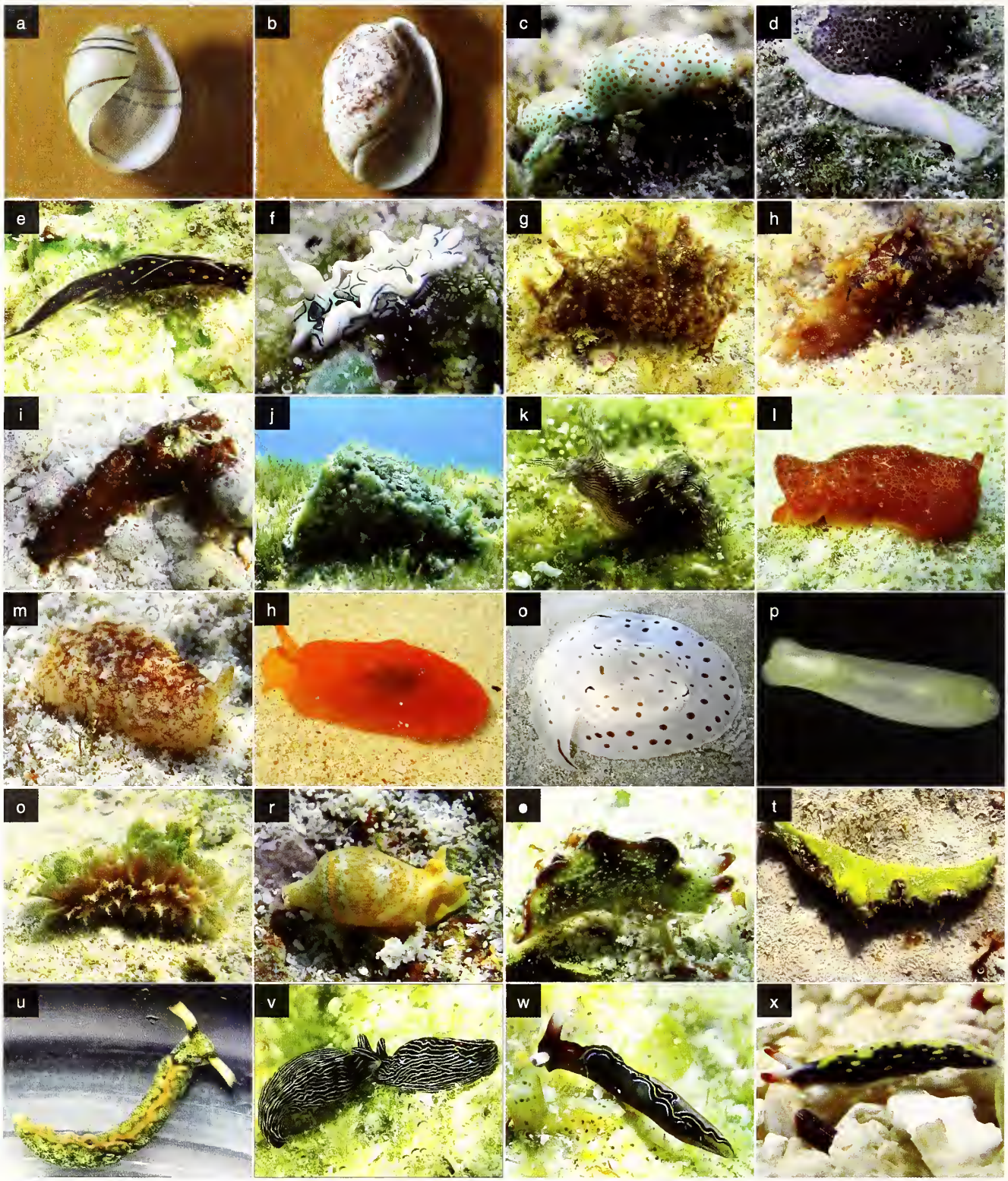

Fig. 1: a. *Hydatina velum*; b. *Bulla ampulla*; c. *Haminoea cymbalum*; d. *Chelidonura electra*; e. *Chelidonura punctata*; f. *Sagaminopteron psychedelicum*; g. *Aplysia dactylomela*; h. *Aplysia parvula*; i. *Dolabrifera dolabrifera*; j. *Dolabella auricularia*; k. *Stylocheilus striatus*; l. *Pleurobranchus peroni*; m. *Pleurobranchus albiguttatus*; n. *Berthellina* cf *delicata*; o. *Euselenops luniceps*; p. *Phanerophthalmus smaragdinus*; q. *Polybranchia orientalis*; r. *Volvatella vigourouxi*; s. *Elysia ornata*; t. *Elysia tomentosa*; u. *Thuridilla carlsoni*; v. *Thuridilla gracilis*; w. *Thuridilla livida*; x. *Thuridilla vatae*

Live animal is uncommon in the lagoon reef.

Status: Uncommon.

Family: **Bullinidae**

***Bulla ampulla* Linnaeus, 1758** (Fig. 1b)

India: Widely distributed both on east and west coast of India.

Extralimital Distribution: Widely distributed in Indo-Pacific region.

Size: 20 mm.

Description: The white shell with profuse dark to light brown mottling is solid and with a large body whorl. Seasonal congregation of this species is common. It mostly occurs on sand flats.

Status: Abundant.

Family: **Haminaeidae**

***Haminoea cymbalum* (Quoy and Gaimard, 1835)** (Fig. 1c)

India: There are only two records of this species in India; Gulf of Mannar (Fontana *et al.* 2001) and Lakshadweep, a new record from the present study.

Extralimital Distribution: Mozambique and Madagascar to Indonesia and Hawaii. Western Pacific and western Indian Ocean.

Size: 25 mm.

Description: Shell is fragile and transparent. Animal is brilliantly coloured. The light green ground colour is profusely spotted with crimson red spots and light orange mottling. Foot is short with crimson red spots. Egg cases are white and glued together with a gelatinous substance. Eggs are laid on dead coral boulders. Individuals form long chains during breeding congregations. Seasonal congregations are common and usually between October to March.

Status: Seasonally abundant.

Family: **Aglajidae**

***Chelidonura electra* Rudman, 1970** (Fig. 1d)

India: Lakshadweep.

Extralimital Distribution: Indonesia Papau New Guinea, Australia, Solomon Is., Madagascar, Tropical Indo-West Pacific.

Size: 25 mm.

Description: A snow-white slug with a bright yellow border. A distinct tail-like extension of the foot is a typical character of the genus.

Status: Rare.

***Chelidonura punctata* Eliot, 1903** (Fig. 1e)

India: Lakshadweep.

Extralimital Distribution: Tanzania, Madagascar, Thailand, Myanmar, Mauritius, Maldives, Reunion Island.

Size: 25 mm.

Description: A deep blue-black slug with bright orange spots, it forms small aggregations during the breeding period. It occurs mostly on coral rubble covered with encrusting algae.

Status: Seasonally common.

Family: **Gastropteridae**

***Sagaminopteron psychedelicum* Carlson and Hoff, 1974** (Fig. 1f)

India: Lakshadweep.

Extralimital Distribution: Japan, South Africa, Philippines, Guam, Malaysia, Seychelles, Papua New Guinea, Red Sea, Fiji, Taiwan.

Size: 4 mm.

Description: It grows up to 12 mm; is associated with *Dysidia* sponges on which it feeds.

Status: Very rare.

Family: **Aplysiidae**

***Aplysia dactylomela* Rang, 1828** (Fig. 1g)

India: Widely distributed in India.

Extralimital Distribution: Red Sea, Africa, Hawaii, South Pacific, Australia, Japan, Sri Lanka, Caribbean.

Size: 600 mm.

Description: A large animal, it is usually seen in large congregations, mostly in shallow waters, during winter months. The shell is considerably reduced in this species and is present inside the body. It shows remarkable colour variations. In Lakshadweep, the dull brown ground colour is dotted with black and white spots. Mantle is bordered in pink. Specimens from Gulf of Kutch are usually dull green with black spots. The pink lining of the mantle flap is also absent. The animals release a purple dye if disturbed.

Status: Abundant.

***Aplysia parvula* Morch, 1863** (Fig. 1h)

India: Lakshadweep.

Extralimital Distribution: Circumtropical.

Size: 8 mm.

Description: A small *Aplysia* it grows up to 20 mm. Body is light brown with white spots. It is also profusely dotted with white. Mantle edge and tips of rhinophores are peacock blue.

Status: Rare.

***Dolabrifera dolabrifera* (Cuvier, 1817)** (Fig. 1i)

India: Lakshadweep.

Extralimital Distribution: Circumtropical.

Size: 150 mm.

Description: A large slug, it is mostly seen in shallow waters of coral reefs. It is nocturnal and remains hidden under algal mass during day time. The animal is light green to dark brown in colour. Rear part of the body is squarish and flattened. Mantle is fully covered with fleshy extensions. Seasonally common, it forms large aggregations for breeding.

Status: Abundant.

Fig. 2: a. *Plakobranchus ocellatus*; b. *Aegires* sp.; c. *Gymnodoris* sp.; d. *Gymnodoris ceylonica*; e. *Gymnodoris alba*; f. *Chromodoris* cf *setoensis*; g. *Chromodoris fidelis*; h. *Glossodoris cincta*; i. *Hypselodoris maculosa*; j. *Hypselodoris infucata*; k. *Hypselodoris maridadilus*; l. *Peltodoris murrea*; m. *Jorunna rubescens*; n. *Jorunna funebris*; o. *Platydoris cruenta*; p. *Halgerda tessellata*; q. *Asteronotus cespitosus*; r. *Phyllidia coelestis*; s. *Phyllidia varicosa*; t. *Phyllidia alyta*; u. *Phyllidia marindica*; v. *Phyllidiella pustulosa*; w. *Phyllidiella rosans*; x. *Phyllidiella zeylanica*

***Dolabella auricularia* (Lightfoot, 1786)** (Fig. 1j)

India: Lakshadweep.

Extralimital Distribution: Japan, Red Sea, Africa, Hawai, Galápagos, Australia, Solomon Is., Madagascar.

Size: 300 mm.

Description: A large slug occurring on shallow reefs. Body surface is highly warty. The animal is light green with dark green tubercles or warts on dorsal surface. The rear part of the body is squarish and flattened. Antennae are short.

Status: Common.

***Stylocheilus striatus* (Quoy & Gaimard, 1832)** (Fig. 1k)

India: Lakshadweep.

Extralimital Distribution: Circumtropical, Japan, South Africa, Mexico.

Size: 30 mm.

Description: A small slug seen on coral sand. Large aggregations for short periods are common during winter. Animals are light grey to green with longitudinal lines running across the body up to the foot. Antennae are also lined in black. A close examination will reveal brilliant blue spots circled with a yellowish band.

Status: Seasonally abundant.

Family: Pleurobranchidae

***Pleurobranchus peroni* Cuvier, 1804** (Fig. 1l)

India: Lakshadweep.

Extralimital Distribution: South Africa to Red Sea, Australia, Indonesia, Japan, UAE, Norfolk Is. (South Pacific), New Zealand.

Size: 50 mm.

Description: A large slug with an extremely soft body. The light yellow ground colour is profusely spotted with dark orange spots. Foot is light yellow. Rhinophores are orange and ribbed.

Status: Uncommon.

***Pleurobranchus albiguttatus* (Bergh, 1905)** (Fig. 1m)

India: Lakshadweep.

Extralimital Distribution: South Africa, Japan, Australia, New Caledonia, Red Sea, Reunion Island, Saudi Arabia, Philippines, Red Sea.

Size: 30 mm.

Description: A small slug, it inhabits shallow reef areas, and mostly remains under coral boulders during day time. Mantle has polygonal markings with scattered white triangular markings. Foot and rhinophores have yellowish brown spots.

Status: Common.

***Berthellina* cf *delicata* (Pease, 1861)** (Fig. 1n)

India: Gulf of Kutch.

Extralimital Distribution: Philippines, French Polynesia.

Size: 35 mm.

Description: A small slug, it occurs on reef sand. Body colour is deep orange with light orange foot. Rhinophores are light orange.

Status: Common.

***Euselenops luniceps* (Cuvier, 1817)** (Fig. 1o)

India: Gulf of Mannar, Chennai.

Extralimital Distribution: Philippines to Australia, Fiji, Hawaii, tropical Indo-West Pacific. Also known from South Africa and Tanzania.

Size: 75 mm.

Description: It is a large sea slug which mostly remains on sand flats. The white ground colour is profusely spotted with deep brown spots. When disturbed it quickly disappears under sand. It can swim short distances. Its perfect camouflage makes it difficult to find.

Status: Very Rare.

Family: Smaragdinellidae

***Phanerophthalmus smaragdinus* (Ruppell & Leuckart, 1828)** (Fig. 1p)

India: Lakshadweep.

Extralimital Distribution: Indonesia, Reunion Island, Philippines, Japan.

Size: 15 mm.

Description: This small slug has an internal shell. It inhabits shallow reef areas and mostly remains under coral boulders or coral sand. The animal is light green in colour.

Status: Common.

Family: Polybranchiidae

***Polybranchia orientalis* (Kelaart, 1858)** (Fig. 1q)

India: Gulf of Mannar, Lakshadweep.

Extralimital Distribution: Japan, Sri Lanka, South Africa, Hawaii, New Caledonia, Australia.

Size: 30 mm.

Description: A small nocturnal slug seen in reefs. Animal is translucent green with dark green cerata. In some individuals, cerata colour at the base is light brown to cream. Body surface bears many leaf-like cerata. On slightest physical touch, the animal automizes the cerata. It lays eggs under dead coral rocks, and the egg mass is white in colour. Egg cases are laid in circular rings.

Status: Common.

Family: Volvatellidae

***Volvatella vigourouxi* (Montrouzier in Souverbie, 1861)** (Fig. 1r)

India: Lakshadweep.

Extralimital Distribution: Australia, New Caledonia.

Size: 20 mm.

Fig. 3: a. *Phyllidiopsis phiphiensis*; b. *Phyllidiopsis striata*; c. *Phyllidiopsis gemmata*; d. *Dendrodoris tuberculosa*; e. *Dendrodoris nigra*; f. *Actinocyclus verrucosus*; g. *Marianina rosea*; h. *Flabellina bicolor*; i. *Phestilla lugubris*; j. *Pteraeolidia ianthina*; k. *Herviella affinis*; l. *Herviella albida*

Description: It is a shelled sacoglossan sea slug. Shell is external, delicate and transparent. The animal is yellow with red spots. It is active during day and seen in shallow lagoon reef. It was found in the pool with thick growth of *Caulerpa racemosa*.

Status: Uncommon.

Family: **Elysiidae**

***Elysia ornata* (Swainson, 1840)** (Fig. 1s)

Syn: *Elysia grandifolia* Kelaart, 1858

India: Gulf of Mannar, Gulf of Kutch, Andaman and Nicobar.

Extralimital Distribution: South Africa to Maldives, Australia to Hawaii, Red Sea to Polynesia, Norfolk Is. (South Pacific), Indonesia, Taiwan, French Polynesia, Circumtropical.

Size: 20 mm.

Description: These small sea slugs are herbivorous. They feed by sucking sap from green algae *Caulerpa racemosa* and *Codium* sp. The species shows remarkable colour variation. It is usually a translucent green with a black parapodial margin and a submarginal yellow or orange band. Body is covered with numerous black and white dots. The specimens from Gulf of Kutch are much lighter in colour and usually light green with black dots. Tips of rhinophores are deep purple in colour.

Status: Common.

***Elysia tomentosa* Jensen, 1997** (Fig. 1t)

India: Gulf of Kutch, Ratnagiri.

Extralimital Distribution: South Africa, Indo-West Pacific.

Size: 40 mm.

Description: A large *Elysia* seen on coral sand, it is deep green yellow in colour. The parapodia are lined by a black and pink band. Rhinophores are reddish brown. They usually occur among *Caulerpa racemosa*.

Status: Common.

***Thuridilla carlsoni* Gosliner, 1995** (Fig. 1u)

India: Lakshadweep.

Extralimital Distribution: New Caledonia, Papua New Guinea, Australia, Hawaiian Islands, Marshall Island, Indonesia, Philippines.

Size: 20 mm.

Description: These small sacoglossan slugs are herbivorous. Body bears green spots on a cream background. The parapodial flaps have a cream coloured edge. The rhinophores are cream with green base and light brown tips.

Status: Rare.

***Thuridilla gracilis* (Risbec, 1828)** (Fig. 1v)

Syn: *Thuridilla ratna* (Marcus, 1965); *Thuridilla bayeri* (Marcus, 1965)

India: Lakshadweep.

Extralimital Distribution: Madagascar to Marshall Is., Papua New Guinea, Guam, Japan, Maldives, Philippines, Coral Sea, Polynesia to Red Sea.

Size: 20 mm.

Description: It is a small slug mostly active during late evenings. Animal is dark reddish brown in colour with bright yellow longitudinal lines. Brilliant blue spots also lie scattered on the surface. Parapodia are bright red, which can be seen only when the flaps are open.

Status: Abundant.

***Thuridilla livida* (Baba, 1955)** (Fig. 1w)

India: Lakshadweep.

Extralimital Distribution: Western Australia, Papua New Guinea, Guam, Marshall Island. Also known from South Africa, Aldabra and the Seychelles.

Size: 10 mm.

Description: It is a very small slug. The body colour is deep reddish brown. Parapodia are bright red, which can be seen only when the flaps are open. The parapodia are lined with a series of longitudinal lines of orange, black and blue. Head is deep red brown, rhinophores are dark brown at the base with white tips. It is a common species from reefs of Lakshadweep.

Status: Uncommon.

***Thuridilla vatae* (Risbec, 1928)** (Fig. 1x)

India: Lakshadweep.

Extralimital Distribution: Vanuatu, Australia, Reunion Island, South Africa, Philippines, Aldabra, Japan, Guam, and Marshall Islands.

Size: 10 mm.

Description: These small sacoglossan slugs are herbivorous. The body is blue black and profusely spotted with yellow. The rhinophores are white with red tips.

Status: Rare.

***Plakobranchus ocellatus* Hassett, 1824** (Fig. 2a)

India: Gulf of Kutch, Andaman.

Extralimital Distribution: Red Sea, Thailand, Japan, Australia to Hawaii, Solomon Is., South Africa, Philippines, Indonesia.

Size: 40 mm.

Description: It is a herbivorous slug. Body surface is very slimy. The species shows wide colour variation. The parapodia are light brown dotted with yellow spots. These spots are encircled with white rings. The base of parapodia bears large light blue spots encircled by black ring. These small sea slugs are burrowing in nature. They prefer sand flats with silty substrate.

Status: Abundant.

Family: **Notodorididae**

***Aegires* sp.** (Fig. 2b)

India: Lakshadweep.

Extralimital Distribution: Indonesia to Australia, Lord Howe Is. (South Pacific), Norfolk Is., Japan.

Size: 60 mm.

Description: Species from genus *Aegires* are significantly different being sluggish and having a tough leathery skin as compared to soft bodies of other nudibranchs. They feed on calcareous sponges. It is known that young individuals have black rhinophores, whereas adults have yellow. In young individuals, body surface is dotted with black spots, whereas the adult is uniformly yellow. The specimen is collected at 20 m depth. It is an uncommon species from Lakshadweep.

Status: Uncommon.

Family: **Gymnodorididae**

***Gymnodoris* sp.** (Fig. 2c)

India: Lakshadweep.

Extralimital Distribution: Not known.

Size: 30 mm.

Description: It is a small and uncommon sea slug. Body colour is yellow, profusely spotted with red spots. Rhinophores are yellow and ribbed. Gills are centrally placed on the dorsal side.

Status: Uncommon.

***Gymnodoris ceylonica* Kelaart, 1885** (Fig. 2d)

India: Gulf of Mannar.

Extralimital Distribution: Australia to Japan and across to Red Sea. Indo-West Pacific.

Size: 55 mm.

Description: Large congregations of this species can be seen in shallow lagoon waters of Lakshadweep during October-November. Mostly present on sandy substrate. The white-coloured body is profusely spotted with red spots. The foot has bright red margin. Gills are centrally placed. Body is transparent to the extent that internal body organs, as well as yellow strands of egg capsules, are clearly visible. It prefers dead, broken coral pieces to lay eggs. Eggs are laid in yellow colour strands on coral rubble. They feed on *Stylocheilus striatus*.

Status: Seasonally common.

***Gymnodoris alba* (Bergh, 1877)** (Fig. 2e)

India: Lakshadweep.

Extralimital Distribution: Japan, China, Indonesia, Australia, Hawaii, Singapore, Philippines, Southern Africa.

Size: 20 mm.

Description: It is a small sea slug and mostly found on sandy substrate. The light orange or cream coloured body is profusely spotted with bright orange spots. Rhinophores are white or pale orange. Gills are white.

Status: Uncommon.

Family: Chromodorididae

***Chromodoris* cf *setoensis* Baba, 1938** (Fig. 2f)

India: Lakshadweep.

Extralimital Distribution: Northern Indian Ocean, West Pacific, Sri Lanka, Arabian Sea, Lord Howe Is. (South Pacific).

Size: 16 mm.

Description: It is a tiny sea slug from reefs. Ground colour is white with a highly decorated surface. Mantle margin is deep orange. A row of deep purple spots along mantle margin are distinctly visible. Three white lines run longitudinally on the back of which one is centrally positioned. All the three lines meet each other at both the ends. Rhinophores and gills are white and ribbed. Foot is short and white in colour. However, Rudman (1986) considers it as a colour form of *C. decora* (Pease 1860).

Status: Uncommon.

***Chromodoris fidelis* (Kelaart, 1858)** (Fig. 2g)

India: Lakshadweep, Andaman.

Extralimital Distribution: New Caledonia, Hong Kong, Japan, Red Sea, Australia, Seychelles, Indonesia, Malaysia, Papua New Guinea.

Size: 35 mm.

Description: The base colour is white with brilliant deep red colour undulating margin. The white and red colour is separated by a continuous black band. Foot is white. Rhinophores and gills are black and ribbed.

Status: Uncommon.

***Glossodoris cincta* (Bergh, 1888)** (Fig. 2h)

India: Lakshadweep.

Extralimital Distribution: Red Sea to Tanzania across to Japan and Fiji, Papua New Guinea, Australia, Maldives, Hong Kong.

Size: 60 mm.

Description: A medium-sized sea slug that remains inside crevices during the day. The species has three colour forms: Red Sea-East Africa; Maldives-N. Australia and W. Pacific. The body colour is deep red brown. Mantle flaps are frilled and brilliant blue and yellow. Foot is deep red brown with a blue margin. Rhinophores are ribbed and blue with a red base. Gills are white with blue edge.

Status: Uncommon.

***Hypselodoris maculosa* (Pease, 1871)** (Fig. 2i)

Syn: *Chromodoris decorata* (Risbec, 1928)

India: Lakshadweep.

Extralimital Distribution: Tanzania, Red Sea, Philippines, Australia, China, Vietnam, Japan, Indonesia, Papua New Guinea, Lord Howe Is. (South Pacific).

Size: 30 mm.

Description: The ground colour is white with a brilliant deep red and undulating margin. Head and tail portion is dotted with white spots. Foot is light purple with white spots. Rhinophores are stalked, white and ribbed with two distinct orange bands. Gills are white with two distinct orange bands.

Status: Uncommon.

***Hypselodoris infucata* (Ruppell & Leuckart, 1828)** (Fig. 2j)

India: Gulf of Kutch.

Extralimital Distribution: Indo-West Pacific, India, Red Sea, Indonesia, Vietnam, New Caledonia, Israel. South Africa, Philippines.

Size: 30 mm.

Description: The ground colour is light purple grey profusely spotted with black and yellow spots. Rhinophores are red and finely ribbed. Gills are white with a red margin.

Status: Very rare.

***Hypselodoris maridadilus* Rudman, 1977** (Fig. 2k)

India: Lakshadweep.

Extralimital Distribution: Maldives, Tanzania, South Africa, Mauritius, Kenya, Red Sea, Hawaii.

Size: 20 mm.

Description: It is a small and brilliantly coloured sea slug. Five purple-violet bands are present on the yellow orange ground colour. The foot and mantle have a purple border. Rhinophores and gills are deep orange red.

Status: Very Rare.

Family: Discodorididae

***Peltodoris murrea* (Abraham, 1877)** (Fig. 2l)

Syn: *Peltodoris mauritiana* Bergh, 1889

India: Gulf of Kutch.

Extralimital Distribution: Maldives, Mauritius, Reunion to New Caledonia and Japan.

Size: 30 mm.

Description: A small *Peltodoris* usually seen in shallow pools and under coral boulders. Body is white with a few black spots. Rhinophores are yellow.

Status: Uncommon.

Family: Kentrodorididae

***Jorunna rubescens* Bergh, 1876** (Fig. 2m)

Syn: *Kentrodoris rubescens* (Bergh, 1876)

India: Lakshadweep.

Extralimital Distribution: Mauritius, Sri Lanka, Australia, Papua New Guinea, Indonesia, Malaysia, Philippines, Solomon Is., Japan, Vietnam.

Size: 200 mm.

Description: This large slug is nocturnal and can be encountered easily in shallow lagoons of Lakshadweep during night dives. Body is soft. Brachial pocket is large which encloses gills and is present in the centre of the body. Rhinophores are ribbed and enclosed in a large pocket. Ground

colour is creamy pink with irregular longitudinal brown lines. Egg capsules are pink and laid in circular rings.

Status: Abundant.

***Jorunna funebris* (Kelaart, 1858)** (Fig. 2n)

India: Gulf of Kutch, Andaman and Nicobar, Gulf of Mannar, Lakshadweep.

Extralimital Distribution: Red Sea, Oman, Maldives, Australia to Japan, Papua New Guinea, Hong Kong, Singapore.

Size: 50 mm.

Description: The surface of this sea slug has a rough texture, a typical character of the genus. Black rings present on the white body are rough to touch. Rhinophores are black and ribbed with a white base. Gills are black. Breeding pairs are common in shallow lagoons of Lakshadweep during winter.

Status: Abundant.

Family: Platydorididae

***Platydoris cruenta* (Quoy and Gaimard, 1832)** (Fig. 2o)

Syn: *Platydoris striata* (Kelaart, 1858)

India: Lakshadweep.

Extralimital Distribution: Red Sea, Christmas Island, Indo-West Pacific.

Size: 20 mm.

Description: It is a small, bright yellow orange slug profusely marked with bright red to brown irregular lines. Rhinophores are yellow and highly ribbed. Gills are yellow with brown margin.

Status: Uncommon.

Family: **Doridiidae**

***Halgerda tessellata* (Bergh, 1880)** (Fig. 2p)

India: Lakshadweep.

Extralimital Distribution: Madagascar, Kenya, Thailand to Micronesia, Australia, Maldives, Mozambique, South Africa and East Africa, Japan.

Size: 20 mm.

Description: This small sea slug is abundantly seen in Lakshadweep reefs. It is mostly active in the late evening. The body colour is deep orange yellow with serrated outcrops. Surface bears dark brown squarish and large spots, which are scattered with silvery white spots. Rhinophores are stalked, ribbed and black in colour. A black line runs from the tip of the rhinophores to the bottom of the rhinophores. Gills are brown; foot is long and has a median brown line.

Status: Abundant.

***Asteronotus cespitosus* (Hasselt, 1824)** (Fig. 2q)

Syn: *Doris cespitosus* Van Hasselt, 1824, *D. mauritiana* Quoy & Gaimard, 1832, *D. foetida* Pease, 1860.

India: Lakshadweep, Andaman.

Extralimital Distribution: Australia, Red Sea, Hawaii, Tanzania, UAE, Maldives, Japan, Sri Lanka, Chagos, Seychelles, Mauritius, Indonesia.

Size: 200 mm.

Description: It is a large sea slug. Light yellow brown in colour, surface is highly warty. Rhinophores are with short stalk, brown in colour and highly ribbed. Gills are feathery and brown in colour. Red semi-circular band on the foot is diagnostic of this species. Egg case is brilliant red in colour.

Status: Common.

Family: **Phyllidiidae**

***Phyllidia coelestis* Bergh, 1905** (Fig. 2r)

India: Lakshadweep, Andaman.

Extralimital Distribution: South Africa to South China Sea, Australia to Fiji, Philippines, Japan, Papua New Guinea, Indonesia, Malaysia, Sri Lanka, Pacific Ocean, Indo-West Pacific Ocean.

Size: 60 mm.

Description: Body surface is highly warty and lacks dorsal gill. The base colour is blue to grey blue. The dorsal surface has three black bands of which the central black band has yellow tubercles and is broken. The rhinophores are yellow. The foot sole is grey and has no black line or markings as seen in *P. varicosa* and *P. elegans*.

Status: Abundant.

***Phyllidia varicosa* Lamarck, 1801** (Fig. 2s)

Syn: *Phyllidia arabica* Ehrenbergh, 1831; *Phyllidia trilineata* Cuvier, 1804a; *Phyllidia borbonica* Cuvier, 1804b; *Phyllidia fasciolata* Bergh, 1869; *Phyllidia honloni* Risbec, 1956.

India: Lakshadweep, Andaman.

Extralimital Distribution: Mauritius, Seychelles, Red Sea, Sri Lanka to Hawaii, Japan, Africa, Papua New Guinea, Thailand, Malaysia, Australia.

Size: 90 mm.

Description: It is a large slug, and as in all other members of the family, the body surface is highly warty and lacks dorsal gills. The species shows remarkable variation in colour and body pattern. The rhinophores are yellow. The foot sole has a broken black median line.

Status: Abundant.

***Phyllidia alyta* Yonow, 1996** (Fig. 2t)

India: Lakshadweep, Andaman.

Extralimital Distribution: Maldives.

Size: 90 mm.

Description: It is a large slug. Dorsal surface bears four longitudinal black lines. Of these, the central two begin just behind the rhinophores till the anal papilla. A black band is distinctly visible connecting both rhinophores. The rhinophores are light to deep yellow or orange-yellow. The foot sole has a broken black median line.

Status: Common.

***Phyllidia marindica* (Yonow and Hayward, 1991)** (Fig. 2u)

Syn: *Fryeria ruppellii* Bergh, 1889; *Fryeria pustulosa* Risbec, 1929.

India: Lakshadweep.

Extralimital Distribution: Thailand, Western Australia, Eastern Africa, Maldives.

Size: 20 mm.

Description: The base colour varies from black, blue to yellow. The dorsal surface bears several laterally running black stripes. Dorsal surface also bears a single median longitudinal ridge. Two black bands run on either side of this ridge. The rhinophores are yellow to gold in colour. Foot sole have no markings.

Status: Uncommon.

***Phyllidiella pustulosa* (Cuvier, 1804)** (Fig. 2v)

Syn: *Phyllidia verrucosa* Hasselt, 1824; *Phyllidia albonigra* Q & G, 1832; *Phyllidiella nobilis* Bergh, 1869; *Phyllidia spectabilis* Collingwood, 1881; *Fryeria varaibilis* Collingwood, 1881; *Phyllidia rotunda* Eliot, 1904; *Fryeria pustulosa* (Cuv).

India: Lakshadweep, Andaman.

Extralimital Distribution: Red Sea to Hawaii, Japan, Malaysia, Thailand, Indonesia, Australia, Western Pacific, Micronesia, Papua New Guinea, Fiji.

Size: 60 mm.

Description: It is a large sea slug. The base colour is black with pink pustules or tubercles, which are usually clustered in three. The pustules on the surface show variation in pattern. The rhinophores are black. Foot sole is grey.

Status: Common.

***Phyllidiella rosans* (Bergh, 1873)** (Fig. 2w)

Syn: *Phyllidia nigra* Pease, 1868; *Phyllidia bourgini* Risbec, 1928; *Phyllidia soria* Er. Marcus & Ev. Marcus, 1970; *Phyllidiopsis* cf. *striata* Edmunds, 1972; *Phyllidia mediocris* Yonow & Hayward, 1991.

India: Lakshadweep.

Extralimital Distribution: East Africa, Reunion, Maldives to Hawaii, Tahiti, Seychelles, Japan.

Size: 35 mm.

Description: Among the *Phyllidiella* this is the most common sea slug. It shows remarkable variations in colour and pattern. Dorsum is black with longitudinal pink ridges. The rhinophores are black with pale pink stalk. The foot sole has numerous tiny spots.

Status: Abundant.

***Phyllidiella zeylanica* (Kelaart, 1859)** (Fig. 2x)

Syn: *Phyllidia ceylanica* Bergh, 1869; *Phyllidia nobilis* Eliot, 1904; *Phyllidia varicosa* Farran, 1905; *Phyllidia catena* Pruvot-Fol, 1956; *Phyllidia seriata* Pruvot-Fol, 1957a; *Phyllidia empelia* Yonow, 1984a: *Phyllidia meandrina* Yonow & Hayward, 1991; *Phyllidia honloni* Wells *et al.*, 1990.

India: Gulf of Kutch, Lakshadweep, Andaman.

Extralimital Distribution: Western Pacific, Seychelles, Thailand. Reunion, Eastern Africa.

Size: 50 mm.

Description: A medium-sized *Philidiella* which resembles *P. rosans* closely. The dorsal surface is black with pink ridges. The rhinophores are black. The foot sole is white.

Status: Common.

***Phyllidiopsis phiphiensis* Brunckhorst, 1993** (Fig. 3a)

India: Lakshadweep.

Extralimital Distribution: Known only from Andaman Sea, Northern Indian Ocean and Thailand. Madagascar.

Size: 20 mm.

Description: A small sea slug usually seen below 8 m depth. White rhinophores are diagnostic along with three black stripes on the dorsal surface. The marginal areas have black spots. The species is named after the locality from where it was first described 'Phi Phi Island'.

Status: Rare.

***Phyllidiopsis striata* Bergh, 1888** (Fig. 3b)

India: Lakshadweep.

Extralimital Distribution: Red Sea, Thailand to Marshall Is., Japan, Papua New Guinea, and Micronesia.

Size: 15 mm.

Description: A small sea slug. The dorsal surface is white with four black longitudinal lines. Three tuberculate ridges originate from anus opening. The central ridge terminates just before rhinophores and remaining two run through rhinophoral openings. The rhinophores are lemon yellow. Black marginal dots are also visible. The specimen was seen feeding on dead giant clam flesh.

Status: Rare.

***Phyllidiopsis gemmata* (Pruvot-Fol, 1957)** (Fig. 3c)

India: Lakshadweep.

Extralimital Distribution: Thailand, Indonesia, Reunion Island.

Size: 40 mm.

Description: This elegant species is commonly seen. The background colour varies from ink to grey. The dorsal surface bears four distinct black lines of which the outermost extend to the mantle edge. Rhinophores are black with a pink band at the base. Foot sole is grey.

Status: Common.

Family: **Dendrodorididae**

***Dendrodoris tuberculosa* (Quoy & Gaimard, 1832)** (Fig. 3d)

India: Lakshadweep, Andhra Pradesh.

Extralimital Distribution: Red Sea to Australia, Hawaii, Japan, South Pacific.

Size: 200 mm.

Description: A large sea slug usually seen in shallow pools and under rocks. They prefer muddy reefs. These slugs produce a powerful toxin that can affect skin and eyes, and gives a severe burning sensation. Surface is extremely warty, and dark brown with white patches. The lower part of the body has white spots, which is diagnostic for the species. Rhinophores are stalked. The stalk is dark brown and the rhinophores light brown in colour. Gills are light brown, leafy and highly branched.

Status: Uncommon.

***Dendrodoris nigra* (Stimpson, 1855)** (Fig. 3e)

India: Lakshadweep.

Extralimital Distribution: Red Sea to Australia, Fiji, South Africa, Thailand, New Zealand, Japan, China, Hong Kong, Indonesia to Hawaii.

Size: 80 mm.

Description: A large and black coloured sea slug usually seen in shallow pools and under rocks. These sea slugs are nocturnal and can be seen during early mornings and late evenings. Rhinophores bear white tips in adults. Juveniles have red band on black mantle.

Status: Abundant.

Family: **Actinocyclidae**

***Actinocyclus verrucosus* Ehrenberg, 1831** (Fig. 3f)

India: Lakshadweep.

Extralimital Distribution: Red Sea, Madagascar, western Pacific to Hawaii.

Size: 60 mm.

Description: Not much is known about this species. Compared to other sea slugs this species has a tough leathery mantle. The dark brown mantle is also covered with rounded tubercles. It is nocturnal and usually seen under coral boulders.

Status: Rare.

Family: **Tritoniidae**

***Marianina rosea* (Pruvot-Fol, 1930)** (Fig. 3g)

India: Lakshadweep.

Extralimital Distribution: Australia, New Caledonia, Marianas Is., South Africa, Indonesia.

Size: 10 mm.

Description: It is a very beautiful and tiny sea slug found mostly under coral rocks. It feeds primarily on hydroids. Base colour is deep pink with white cerata. Rhinophores are in pockets and orange in colour. Oral tentacles are white with pink base.

Status: Seasonally common.

Family: Flabellinidae

***Flabellina bicolor* (Kelaart, 1858)** (Plate 3h)

India: Lakshadweep.

Extralimital Distribution: Widely distributed in Indo-Pacific, Papua New Guinea, Japan, Hong Kong, Maldives, South Africa to Hawaii.

Size: 20 mm.

Description: A tiny sea slug usually seen under rocks or among dead coral branches. It has a long and narrow body with numerous mantle outgrowths known as cerata on the body. Cerata are in pairs and have a distinct orange band on it. Besides cerata, the head also has a pair of oral tentacles. Rhinophores are bulbous and brown in colour. These are predators feeding on hydroids.

Status: Seasonally abundant.

Family: Tergipedidae

***Phestilla lugubris* (Bergh, 1870)** (Fig. 3i)

India: Lakshadweep.

Extralimital Distribution: Tanzania, Indonesia, Australia, Hawaii, Japan, Vietnam, Hong Kong.

Size: 45 mm.

Description: These sea slugs are closely associated with *Porites lutea*, they feed on the polyps of this species. Body colour is light brown. Body surface bears numerous cerata. Each ceras is bulbous in nature with distinct white bands and ringed nodes.

Status: Uncommon.

***Pteraeolidia ianthina* (Angas, 1864)** (Fig. 3j)

India: Lakshadweep, Gulf of Kutch.

Extralimital Distribution: Australia, Singapore, China, Vanuatu, Fiji, Japan, Hawaii, Madagascar, Seychelles.

Size: 50 mm.

Description: It is a large aeolid occuring on coral sand. Body is covered with numerous cerata. Tentacles have distinct purple bands. Nothing is known about this species in India.

Status: Very rare.

Family: Facelinidae

***Herviella affinis* Baba, 1960** (Fig. 3k)

India: Lakshadweep.

Extralimital Distribution: Japan.

Size: 10 mm.

Description: It is a small slug found on hydroids. Oral tentacles and rhinophores are smooth. Rhinophores have black speckling at the lower half and a black band. Upper half of the rhinophores is translucent yellowish white. The cerata are spindle shaped and bulbous just below the tip and arranged in single rows. The cerata are transparent with distal half being white with a central band of orange.

Status: Rare.

Herviella albida **Baba, 1966** (Fig. 3l)

India: Lakshadweep.

Extralimital Distribution: Australia, Japan.

Size: 15 mm.

Description: It is a small sea slug usually seen under coral boulders. It feeds on sea anemones. The oral tentacles and cerata are long, slender, and transparent with white tips. Cerata are long and bulbose at the centre with white bands at the top and centre. The body is transparent with white diamond shaped marks on the mantle.

Status: Rare.

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BREEDING ECOLOGY AND NEST-SITE SELECTION OF YELLOW-BROWED BULBUL *IOLE INDICA* IN WESTERN GHATS, INDIA

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The breeding biology and nest-site selection of Yellow-browed Bulbul *Iole indica*, an endemic to the Western Ghats and Sri Lanka biodiversity hotspot, was studied in the Silent Valley National Park, Kerala, from 2002 to 2005. Breeding occurred in the dry season from mid-November to the end of April with peak egg-laying in January and February. Nests were open cups placed 0.5-6.2 m from the ground in plants 0.6-8.0 m tall. Birds laid clutches of 2-3 eggs and broods hatched synchronously. Overall nesting period lasted for about a month with 3-7 days for nest construction, 11-13 days for incubation and 12-13 days for nestling period. Mayfield nest success was 17.21%. Predation was the main known cause of nest failure, and mortality was higher during the egg stage compared to nestling stage. Yellow-browed Bulbuls used large number of plants (32 species) as nest substrates. Successful nests were characterised by high nest concealment compared to that of the unsuccessful nests. However, information on the abundance and behaviour of predators and experimental manipulations are required for a comprehensive understanding of nest-site selection process.

Key words: breeding biology, *Iole indica*, life history traits, nesting success, Pycnonotidae, tropical rainforest, Yellow-browed Bulbul

INTRODUCTION

Bulbuls (Family Pycnonotidae) are one of the large groups of passerines of the Old World tropics, widespread in southern Asia, Africa, Madagascar, islands of the Western Indian Ocean (Sibley and Monroe 1990; Fishpool and Tobias 2005). They occupy a broad range of habitats from semi-arid deserts to rainforests, with centre of diversity in the Afrotropical and Sundaic regions. Of the 27 genera currently treated within the Family Pycnonotidae, 11 are exclusively Asian, 14 are restricted to Africa and islands of the Western Indian Ocean while the remaining 2 occur in both continents. The Family comprises nearly 140 species and 355 subspecies (Fishpool and Tobias 2005; Woxvold *et al.* 2009) with several complex taxonomic uncertainties (Pasquet *et al.* 2001; Fishpool and Tobias 2005; Moyle and Marks 2006). Only a few widespread and lowland Pycnonotids have been well-studied, in their native and other introduced ranges. Information on the ecology of mid and higher elevation bulbuls are restricted mostly to natural history notes (Fishpool and Tobias 2005). Moreover, information on the life history traits, including developmental rates and nesting success, for majority of the species is not known. Of the 22 species of bulbuls recorded in India (Rasmussen and Anderton 2005), 8 are seen in southern or peninsular India. Most of these species are common in their habitat and are open-cup nesters. Detailed examination of the breeding ecology of these birds is important to understand the evolution of life history strategies of open-cup nesting birds in the tropics.

The Yellow-browed Bulbul *Iole indica* is an endemic to the Western Ghats and Sri Lanka (Grimmett *et al.* 1999). It is one of the most abundant, uniformly distributed species in the tropical rainforests of Western Ghats at an optimum zone of 1,000-1,500 m (Ali and Ripley 1987; Raman 2003), yet relatively little is known of its biology, compared to that of other bulbul species. They are sedentary residents in moist forests with higher levels of frugivory and generalism in the diet compared to other high altitude species (Ali and Ripley 1987; Fishpool and Tobias 2005; Balakrishnan 2007).

The aim of the present study was to provide a detailed description of the breeding ecology of Yellow-browed Bulbul in southern Western Ghats. The specific objectives were to obtain information on the breeding season, nest dimensions, clutch sizes, developmental periods, breeding success, causes of nest failures and nest-site characteristics.

METHODS

Study area

The study was carried out between December 2002 and May 2005 in the core area of Silent Valley National Park (11° 00'-11° 15' N; 76° 15'-76° 35' E; 90 sq. km; 600-2,383 m above msl), and surrounding buffer zones in the Western Ghats, India. Majority of the study area is covered by the 'West coast tropical evergreen forest', with altitudes ranging from 600 to 1,500 m above msl along the Kunthi river and its tributaries, where the breeding habitat of the species is mainly located. The forest canopy is dominated by large evergreen trees, such as *Cullenia exarillata*, *Canarium strictum*, *Calophyllum elatum*, *Eleocarpus serratus*, *Myristica dactyloides*, *Mesua ferrea*, *Jumbosa munronii*, *Syzigium* spp., *Palaquium ellipticum*, *Persea macrantha* and *Poeciloneuron* sp. The sub-

canopy and understorey is dominated by species such as *Clerodendrum viscosum*, *Maesa indica*, *Chloranthus brachystachys*, *Ochlandra travancorica* and *Strobilanthes* spp. The study site receives rains from the south-west (May-September) and the north-east (October-December) monsoons. During the study period, annual rainfall ranged from 4,900 to 8,260 mm, with more than half of it occurring during the south-west monsoon. Mean minimum and maximum daily temperatures during the study were 19.83 °C and 25.78 °C respectively.

Nest searching and monitoring

During the study, nests of Yellow-browed Bulbuls were located by following individuals carrying nesting material or food to the nests and by searching vegetation as described by Martin and Geupel (1993). Once located, the nests were checked everyday with the help of field assistants to determine the time of egg laying, clutch size, start and duration of the development period (incubation and nestling), and fate of the nest. Nests accessible from the ground were monitored using binoculars, while higher nests were checked using a pole and mirror. The clutch initiation dates were determined by direct observation of egg laying or by calculating known hatching dates and mean developmental periods. For calculating the development period, only nests where breeding stage transitions could be observed directly were considered. Nest size parameters, such as inner diameter, external diameter, and height and depth to the nearest centimetre were measured in the field; cup thickness, cup volume and material volume were calculated using these measurements (Soler *et al.* 1998; Balakrishnan 2007). Orientation of the nest around the substrate plant was recorded to the nearest degree using a Suunto MCA-D compass.

Nest-site habitat sampling

During the study, habitats were sampled in 108 Yellow-browed Bulbul nest-sites. Nest height, species, height and girth at breast height (GBH) of the nest substrate were recorded immediately after fledging of the young or predation of a nest. The vegetation structure and other physical variables were quantified within an 11.3 m radius circular plot (0.04 ha) around each nest based on standard methods (James and Shugart 1970; Martin *et al.* 1996). Within each of the plots, tree density (number of all trees >10 cm GBH), mean tree height, mean GBH of all trees, visual estimates of foliage cover at canopy (trees >10 m height), sub-canopy (trees =10 m height), shrub, and ground vegetation layers were measured/calculated. Densities of nest plants, saplings and shrubs were measured within a 5 m radius circular plot (0.008 ha) surrounding the nest. Distance from the nest tree to the adjacent tree, shrub, water and trek path/road was also measured. Nest concealment was estimated visually as a percentage of the nest obscured by foliage, 1 m from the nest in the four cardinal directions and 1 m above the nest. These estimates were averaged to obtain a single percentage for a nest.

Data analyses

Breeding season and clutch size was determined from 153 nests. The breeding seasonality was determined by combining the nesting records of each month during three breeding seasons. The relationship between breeding seasonality and climatic variables were tested using non-parametric Spearman's rank correlation. Climatic data were collected from the Walakkad forest station of the Kerala Forests and Wildlife Department. Variation in nest morphometry in different treatments was compared by analysis of variance (one-way ANOVA). Variations in the nest placement attributes between breeding seasons were tested using Kruskal-Wallis test. Uniform distribution of nest orientations were tested using non-parametric Watson one-sample U^2 test for circular distributions. Watson-Williams test was used to evaluate the hypothesis that successful and failed nests have the same mean orientation (Zar 1999).

Hatching, nestling and breeding success were defined as: the probability that eggs laid would hatch, that hatchlings would fledge, and that eggs laid would survive from laying to fledging, respectively. Nests that produced at least one young were considered as successful. Hatching, nestling and breeding success were calculated as an index of the chick fledged versus eggs laid (Jehle *et al.* 2004). Daily nest survival rates (DSR) were estimated using the Mayfield method (Mayfield 1975). The number of exposure days was calculated from the interval between the day the first egg was laid or the day the nest was found if after laying, and the day of fledging. Daily survival rates and nest success were calculated separately for the developmental periods (incubation and nestling), overall nesting period and breeding seasons. Standard errors for survival rates were calculated based on the methods described in Johnson (1979).

Univariate analyses (*t*-tests) were used to compare nest-site characteristics of successful nest-sites with unsuccessful ones. For these analyses, the data was lumped for all nests due to within-breeding season sample size constraints and means ±SE of untransformed data, are presented for ease of interpretation. All tests were two-tailed, and differences were considered significant at $p<0.05$. Mean ±SD values are reported throughout unless otherwise indicated. All statistical analyses were performed by using SPSS 10.0 (SPSS Inc.) and Oriana 2.0 (Kovach Computing Services).

RESULTS

Start and duration of breeding season

Yellow-browed Bulbul is a resident and early season breeder. Nest building started in mid-November (first

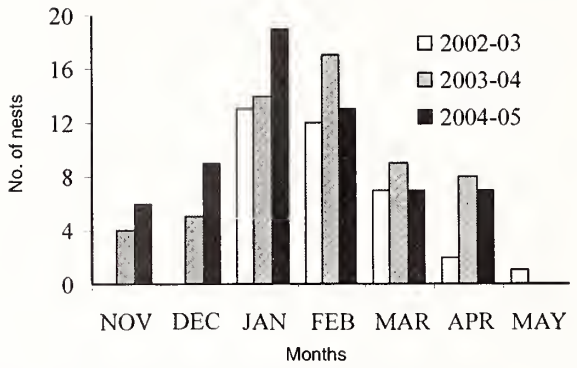

Fig. 1: Breeding season of Yellow-browed Bulbul based on the number of clutches initiated per month during different breeding seasons at Silent Valley National Park

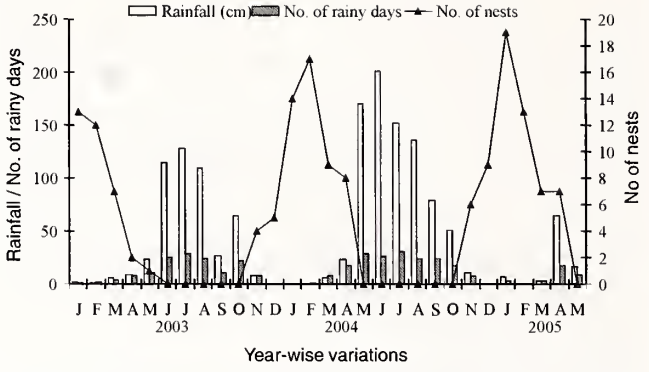

Fig. 2: Relationship between clutch initiations of Yellow-browed Bulbul with monthly rainfall and number of rainy days/month at Silent Valley National Park

observation for the season: November 14, 2003, and November 17, 2004) and laying of the first egg was observed in late November (November 21, 2003 and November 25, 2004). Peak in egg-laying occurred during January and February in all the breeding seasons (Fig. 1). The clutch completion dates for the last nest were observed on May 01, 2003, April 11, 2004 and April 07, 2005. The number of clutches initiated per month was negatively correlated to the monthly rainfall (r_s = -0.826, n=29, p=0.001), and number of rainy days per month (r_s = -0.829, n=29, p=0.001; Fig. 2).

Nest construction, placement and orientation

Nests of Yellow-browed Bulbuls were open cups (outer diameter: 9.35 ±1.42 cm, inner diameter: 6.41 ±0.87 cm, outer nest height: 7.43 ±0.93 cm, cup depth: 5.07 ±0.62 cm, nest thickness: 2.92 ±0.88 cm, cup volume: 452.54 ±154.41 cu. cm, material volume: 971.89 ±417.51 cu. cm, n=108) made of mostly materials available in the vicinity of the nest sites. The structural constituent of the nests were vine tendrils, dry grass blades, dry leaves of *Cinnamomum sulphuratum*, *Chumnianthus* sp., *Hopea parviflora*, *Lasianthus* spp., *Ochlandra travancorica*, *Oreocnide integrifolia* and inflorescence of *Antidesma menasu*. Innermost lining was made with fibrous roots of pteridophytes and other soft material. 80 out of the 108 nests examined were covered with green moss. There was a significant variation in the morphometry of the nests covered with moss and those lacking a moss decoration (Table 1). Both sexes participated in nest building and construction took 3-7 days to complete (mean = 5.42 ±1.24 days, n=12).

On an average, Yellow-browed Bulbuls placed their nests 1.62 ±1.19 m (range: 0.5-6.2 m, n=108) above the ground at a relative height of 0.64 ±0.13 (range: 0.28-0.93, n=108). The relative height is the height of nest in relation to the tree height on which the nest is placed. There was no significant variation in nest height (Kruskal-Wallis, χ^2=5.780, p=0.056), nest plant height (Kruskal-Wallis, χ^2=1.988, p=0.370) and relative height (Kruskal-Wallis, χ^2=4.910, p=0.086) during the different breeding seasons. Mean nest orientation (μ ± SE) was 168.27 ±22.98° and deviated slightly from random (Length of mean vector, r = 0.168; Watson's U^2 = 0.193, p<0.05, n=108; Fig. 3).

Clutch size, incubation and nestling periods

Clutch size of Yellow-browed Bulbul ranged from two to three with 92.16% of nests containing two eggs (mean clutch size: 2.08 ±0.27 eggs, n=153). Eggs were laid in the morning, at about 24 hr intervals. Incubation began with clutch completion and hatching was synchronous within broods. Average length of incubation period was 12.06 ±0.64 days (range: 11-13 days, n=18). Nestling period ranged from 12 to 13 days (mean: 12.76 ±0.44 days, n=17). Overall nesting period from the start of incubation was 24.85 ±0.69 days (range: 24-26, n=13).

Table 1: Variation in the morphometry of nests with moss cover and nests devoid of moss of Yellow-browed Bulbul in Silent Valley National Park

Nest size variables	Nest with moss cover (±SD)	Nest devoid of moss cover (±SD)	*F*	p
Outer diameter (cm)	9.95 ±1.05	7.64 ±1.05	111.228	0.001
Inner diameter (cm)	6.65 ±0.79	5.80 ±0.78	24.236	0.001
Outer depth (cm)	6.49 ±0.74	7.77 ±0.75	60.328	0.001
Inner depth (cm)	5.29 ±0.46	4.44 ±0.59	59.139	0.001
Cup thickness (cm)	3.30 ±0.66	1.84 ±0.42	118.861	0.001
Cup volume (cu. cm)	499.54 ±143.21	318.25 ±96.06	38.651	0.001
Material volume (cu. cm)	1140.11 ±342.30	491.27 ±156.84	93.3	0.001

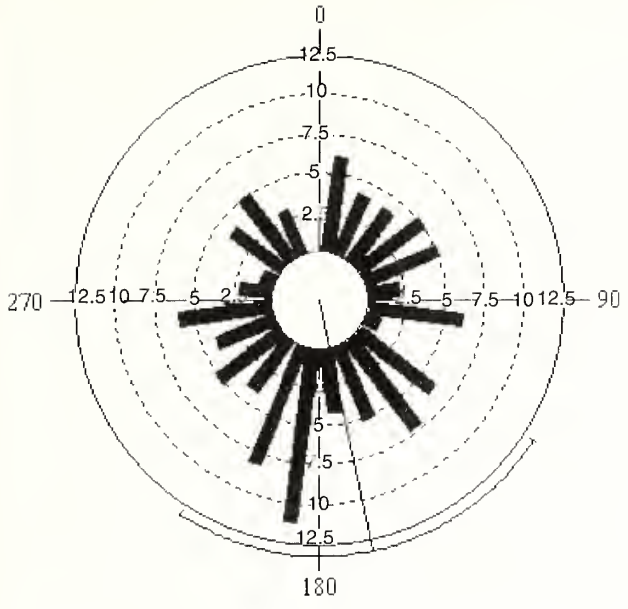

Fig. 3: Nest orientation of Yellow-browed Bulbul in trees used for nesting (n=108 nests, bin width=15°). Dotted circles indicate scale (% of nests)

Nesting success

25 of 108 nests (23.15%) fledged young birds, with successful nests producing 2.12 ±0.33 young. Overall hatching (% eggs hatched), fledging (% hatched chicks fledging) and breeding success (% eggs fledged) were 42.92% (97 of 226 eggs), 54.64% (53 fledged out of 97 hatched) and 23.45%, respectively. Daily survival rates (mean ± SE) were 0.923 ±0.009, 0.949 ±0.011 and 0.932 ±0.007 during the incubation, nestling, and overall nesting periods respectively (Table 2). The Mayfield nest success rate for the entire breeding period was 17.21%. The daily survival rates did not vary between the breeding seasons (Table 3).

Predation was the major cause of nest failure, which is characterised by the complete loss of eggs or nestlings. Of the 83 nest failures, at least 71 nests (>85%) failed due to predation. Predation of eggs and chicks by Common Vine Snake *Ahaetulla nasuta*, White-bellied Treepie *Dendrocitta leucogastra*, and Greater Coucal *Centropus sinensis* were recorded during the study period. Five nests were destroyed by trampling by large vertebrates (Asian Elephant *Elephas maximus*, Sambar *Cervus unicolor*). No brood parasitism was recorded in the clutches examined.

Table 2: Daily nest survival rate and associated variance and nest success of Yellow-browed Bulbul during different reproductive phases, Silent Valley National Park, southern India

Reproductive phase	Exposure days	No. of nests	No. of nest failed	Daily nest survival ± SE	Nest success
Incubation	791	108	61	0.923 ± 0.009	38.17
Nestling	430	47	22	0.949 ± 0.011	50.52
Overall nesting	1221	108	83	0.932 ± 0.007	17.21

Nest-site selection

Yellow-browed Bulbul nests (n=108) were built in at least 32 plant species with more than 52% nests in 6 species (Table 4). The nests without moss decoration were placed in sub-canopy plants such as *Antidesma menasu*, *Callicarpa tomentosa*, *Olea dioica*, *Oreocnide integrifolia* and saplings of *Syzigium* sp., while majority of the nests with moss cover were found in the shrub layer. Nest placement attributes and nest patch characteristics significantly varied between nests covered with moss and those lacking a moss decoration, except for the sub-canopy cover, relative nest height and distance to the trek path/road from the nest (Table 5). However, there was no variation in the success rates between nests covered with moss (23.75%) and those lacking a moss decoration (21.43%). The only significant difference detected between successful and unsuccessful nest-sites was high nest concealment for successful nests (Table 6). Nest orientation also did not vary between the successful (mean vector, μ ±SE = 186.11 ±54.31°, n=25) and failed nests (mean vector, μ ±SE = 163.83 ±24.90°, n=83; Watson-Williams test: $F_{1, 106} = 0.548$, p=0.461).

DISCUSSION

Tropical birds show great heterogeneity of breeding seasons compared to seasonal breeding in temperate species (Moreau 1950; Skutch 1950; Ali and Ripley 1987; Wikelski *et al.* 2000). Food supply, competition, nesting conditions, predation pressure and climatic factors are the ultimate factors known to influence the breeding time. Majority of the pycnonotids occur in the equatorial rainforests and tropical islands, and breed throughout the year and raise several broods (Ali and Ripley 1987; Fishpool and Tobias 2005). Ali and Ripley (1987) reported February to May as the breeding season of Yellow-browed Bulbul. The present study indicates that they start breeding by mid-November and continue throughout the dry season in the Silent Valley National Park. They avoided breeding during the south-west monsoon

Table 3: Daily nest survival rate and associated variance and nest success of Yellow-browed Bulbul during different breeding seasons, Silent Valley National Park, southern India

Breeding season	Exposure days	No. of nests	No. of nest failed	Daily nest survival ± SE	Nest success
2002-2003	265	25	20	0.926 ± 0.016	14.06
2003-2004	476	39	30	0.937 ± 0.011	19.64
2004-2005	480	44	33	0.931 ± 0.012	16.85

months as in the case of other pycnonotids occurring in the area (Balakrishnan 2007; in press). Furthermore, the breeding activities coincide with the general fruiting phenology of the study area, which shows a bimodal fruiting pattern (Balakrishnan 2007). Peak egg laying occurs about one month prior to the peak fruiting during late summer and early south-west monsoon (March-May). Higher levels of frugivory and generalism in the diet could be the reason for the early start of breeding compared to the other high altitude species, such as Square-tailed Black Bulbul *Hypsipetes ganeesa*.

Ali and Ripley (1987) reported that the nests of Yellow-browed Bulbuls are quite unlike that of other pycnonotids and more like a large White-eye's nest. This is true for the nests devoid of moss cover, but nests with moss decoration are larger in size (Table 1) and comparable with that of other bulbul species. More than 92% of nests had two eggs, and the remaining three. Ali and Ripley (1987) also reported the clutch size as two or three (two in Sri Lanka), which is the typical range of most African and Asian species of bulbuls (Fishpool and Tobias 2005). The incubation (12 days) and nestling periods (13 days) fall within the typical range of most species of bulbuls (11-14 days) (Liversidge 1970; Vijayan 1975, 1980; Walting 1983; Ali and Ripley 1987; Hsu and Lin 1997; Krüger 2004; Fishpool and Tobias 2005; Balakrishnan 2007; in press). Overall nesting period from the start of nest construction was about a month. This along with the long breeding season indicates that species raise multiple broods. However, the number of nesting attempts per season was not determined in the present study due to the lack of colour marking of birds.

About 23% nests produced fledglings, which is similar to that of the higher altitude pycnonotids breeding at Silent Valley (Balakrishnan 2007; in press), but higher than that reported for the lowland species, such as White-browed *Pycnonotus lutelolus* (13.2%) and Red-vented Bulbuls *Pycnonotus cafer* (8.3%) in southern India (Vijayan 1975, 1980). The Mayfield nest success rate (17.21%) is also higher in Yellow-browed Bulbul than in Grey-headed (10.79%) and Square-tailed Black (12.84%) Bulbuls breeding in the same habitats (Balakrishnan 2007; in press). However, the nest

Table 4: Plant species used as nest substrates by Yellow-browed Bulbul during 2002-2005 at Silent Valley National Park with their frequency, height characteristics and success rate

Plant species	No. of nests (%)	Nest height in m ± SD	Tree height in m ± SD	Relative height	% successful
Lasianthus ciliatus	17	0.82 ± 0.18	1.34 ± 0.26	0.62 ± 0.12	23.53
Lasianthus jackianus	11	0.95 ± 0.24	1.61 ± 0.31	0.60 ± 0.14	27.27
Agrostistachys borneensis	9	0.92 ± 0.16	1.61 ± 0.31	0.58 ± 0.09	22.22
Antidesma menasu	7	3.37 ± 0.79	5.27 ± 1.51	0.65 ± 0.11	28.57
Olea dioica	7	2.72 ± 0.59	4.12 ± 1.58	0.71 ± 0.18	28.57
Cullenia exarillata	6	1.53 ± 0.59	2.18 ± 0.71	0.70 ± 0.08	33.33
Thottea siliquosa	5	1.20 ± 0.52	2.02 ± 1.13	0.60 ± 0.07	20.00
Clerodendrum viscosum	4	4.88 ± 1.10	7.00 ± 1.09	0.69 ± 0.06	25.00
Psychotria nigra	4	1.69 ± 0.23	2.26 ± 0.26	0.76 ± 0.10	25.00
Syzigium sp. sapling	4	1.38 ± 0.89	2.15 ± 1.57	0.66 ± 0.12	0.00
Chloranthus brachystachys	3	0.83 ± 0.06	1.20 ± 0.20	0.70 ± 0.09	33.33
Pavetta indica	3	1.03 ± 0.25	1.90 ± 0.17	0.55 ± 0.13	33.33
Ancistrocladus heyneanus	2	1.10 ± 0.14	1.60 ± 0.14	0.69 ± 0.03	0.00
Cinnamomum sulphuratum	2	1.95 ± 0.64	4.25 ± 1.06	0.50 ± 0.27	0.00
Eurya nitida	2	0.85 ± 0.21	2.25 ± 0.07	0.50 ± 0.01	50.00
Glochidion ellipticum	2	4.55 ± 0.07	6.25 ± 1.06	0.74 ± 0.11	0.00
Knema attenuata	2	0.60 ± 0.14	0.70 ± 0.14	0.86 ± 0.03	0.00
Litsea floribunda	2	1.10 ± 0.42	1.85 ± 0.50	0.59 ± 0.07	100.00
Oreocnide integrifolia	2	3.85 ± 0.21	6.00 ± 0.71	0.65 ± 0.04	0.00
Saprosma glomerata	2	0.65 ± 0.07	0.75 ± 0.07	0.87 ± 0.01	0.00
Actinodaphne lawsonii	1	1.40	2.00	0.70	0.00
Allophyllus cobbe	1	0.90	1.60	0.56	0.00
Callicarpa tomentosa	1	2.80	4.50	0.62	0.00
Daphniphyllum neilgherrense	1	2.70	3.60	0.75	100.00
Elaeocarpus munronii	1	1.60	1.80	0.89	0.00
Hopea parviflora	1	1.50	2.00	0.75	0.00
Myristica malabarica	1	1.10	2.80	0.39	100.00
Neolitsea scrobiculata	1	1.20	2.50	0.48	0.00
Persea macrantha	1	1.20	1.80	0.67	0.00
Sarcococca coriacea	1	0.80	2.20	0.36	0.00
Strobilanthes foliosus	1	1.60	2.00	0.80	0.00
Unidentified shrub	1	1.30	2.50	0.52	0.00

predation rates are slightly higher than that reported for the tropical passerines (71%) (Robinson *et al.* 2000; Stutchbury and Morton 2001). Nest predation was significantly higher during the incubation stage than in the nestling stage. This is opposition to the predictions of parental activity hypothesis (Skutch 1949), which states that nests may suffer higher predation rates during the nestling stage because of increased parental activity and nestling noise. Higher nest predation during incubation has also been reported in several other species (Martin 1992; Mermoz and Reboreda 1998; Balakrishnan 2007). Moreover, variation in nest-site quality can often influence nest predation, and such effects could mask parental activity effects on nest predation (Martin *et al.* 2000). Predation was the major factor limiting breeding success in Yellow-browed Bulbul, as has been reported for other open-cup nesting passerines (Ricklefs 1969; Martin 1993, 1995). Two species of birds (White-bellied Treepie, Greater Coucal) and one snake species (Common Vine Snake) have been confirmed as nest predators by direct observations. Species such as Black-winged Kite *Elanus caeruleus*, Common Rat Snake *Ptyas mucosus* and Jungle Striped Squirrel *Funambulus tristriatus* are also recorded as nest predators of other bulbul species at Silent Valley (Balakrishnan 2007). Other likely predators include several species of small carnivores, corvids, forest raptors, dusky squirrels and colubrid snakes.

Nests with green moss cover were placed in the shrub layer and had a complex vegetation structure surrounding them compared to that of the nests devoid of moss decoration (Table 5). However, variation in nest placement attributes and vegetation structure between nests covered with moss and those lacking moss decoration did not reflect in the nesting success. Thus, a moss decoration in the shrub layer with more foliage cover and lack of moss cover in nests placed higher off the ground with low foliage cover could be different anti-predator strategies in respective microhabitats (Collias and Collias 1984; Hansell 2000). Yellow-browed Bulbuls seem to be generalists in nest substrate selection and they used at least 32 plant species as nest-sites at Silent Valley. Such generalist habits may have disadvantages like increased nest failures because nesting in more forms of vegetation may expose a bird species to a greater variety of predators, thus lessening the likelihood of evolving efficient anti-predator nesting behaviour (Best and Stauffer 1980). However, higher predation rates are reported for high altitude species, such as Grey-headed Bulbul and Square-tailed Black Bulbul, irrespective of the specificity in the substrates selected for nesting (Balakrishnan 2007; in press). Nest concealment was the only habitat variable that acted as a predictor of nest success in Yellow-browed Bulbul. Similar results were obtained when the successful and unsuccessful nests of two groups (nests covered with moss and nests lacking moss cover) were compared separately. However, it is highly unlikely that a single attribute of nesting habitat can determine the fate of the nests given that nest searching techniques, and ability to detect nest-site patches, vary substantially among predators (Chase 2002). Thus, further information on the predator communities and their behaviour, and experimental manipulations are required to understand factors influencing habitat selection and nest success of Yellow-browed Bulbul.

Table 5: Comparison of the nest-site characteristics of nests with moss cover (n=80) and nests devoid of moss cover (n=28, df=106). Shown are means ± SE of untransformed variables and results of *t*-tests

Variables	Nest with moss cover	Nest devoid of moss cover	*t* (p)
Mean tree height (m)	11.80 ± 0.24	9.33 ± 0.35	-5.340 (0.001)*
Mean tree GBH (cm)	52.05 ± 1.69	39.55 ± 1.91	-4.063 (0.001)*
Tree density (#/plot)	59.18 ± 2.19	41.79 ± 2.53	-4.347 (0.001)*
Per cent canopy cover	59.38 ± 1.27	39.46 ± 3.04	-7.142 (0.001)*
Per cent sub-canopy cover	47.69 ± 1.83	52.14 ± 2.11	1.335 (0.185)
Per cent shrub cover	79.31 ± 1.40	57.86 ± 2.79	-7.455 (0.001)*
Per cent ground cover	71.06 ± 1.16	52.50 ± 3.17	-6.868 (0.001)*
Nest height (m)	1.04 ± 0.04	3.29 ± 0.22	15.480 (0.001)*
Nest plant height (m)	1.72 ± 0.08	4.93 ± 0.34	13.634 (0.001)*
Relative nest height	0.63 ± 0.02	0.68 ± 0.02	1.647 (0.102)
Nest plant GBH (cm)	7.46 ± 0.49	33.54 ± 2.97	13.495 (0.001)*
Nest plant density (#/plot)	9.48 ± 2.43	6.68 ± 1.09	-0.669 (0.505)
Sapling density (#/plot)	34.74 ± 1.82	23.18 ± 1.54	-3.590 (0.001)*
Shrub density (#/plot)	153.82 ± 6.04	41.43 ± 5.31	-10.495 (0.001)*
Nest concealment (%)	76.21 ± 1.16	63.64 ± 2.17	-5.365 (0.001)*
Distance to water (m)	47.61 ± 5.51	306.79 ± 47.16	8.879 (0.001)*
Distance to trek path (m)	34.48 ± 9.83	8.10 ± 2.37	-1.577 (0.118)
Distance to adjacent tree (m)	1.39 ± 0.07	2.09 ± 0.16	4.590 (0.001)*
Distance to adjacent shrub (m)	0.70 ± 0.04	1.59 ± 0.14	7.925 (0.001)*

* significant values

Table 6: Comparison of the nest-site characteristics of successful nests (n=25) and unsuccessful nests (n=83, df= 106)

Variables	Successful	Unsuccessful	*t* (p)
Mean tree height (m)	11.23 ± 0.47	11.14 ± 0.26	0.164 (0.870)
Mean tree GBH (cm)	51.33 ± 3.17	48.05 ± 1.62	0.959 (0.340)
Tree density (#/plot)	53.32 ± 3.32	55.07 ± 2.26	-0.389 (0.698)
Per cent canopy cover	56.60 ± 3.17	53.49 ± 1.67	0.884 (0.379)
Per cent sub-canopy cover	45.60 ± 3.78	49.82 ± 1.53	-1.216 (0.227)
Per cent shrub cover	76.20 ± 2.37	73.01 ± 1.89	0.867 (0.388)
Per cent ground cover	67.80 ± 2.66	65.78 ± 1.67	0.598 (0.551)
Nest height (m)	1.65 ± 0.23	1.61 ± 0.13	0.147 (0.883)
Nest plant height (m)	2.62 ± 0.38	2.53 ± 0.19	0.239 (0.812)
Relative nest height	0.64 ± 0.02	0.64 ± 0.02	-0.168 (0.867)
Nest plant GBH (cm)	14.92 ± 2.95	14.01 ± 1.58	0.274 (0.784)
Nest plant density (#/plot)	6.80 ± 1.27	9.34 ± 2.35	-0.584 (0.560)
Sapling density (#/plot)	29.04 ± 2.82	32.55 ± 1.74	-0.996 (0.321)
Shrub density (#/plot)	126.40 ± 12.09	124.17 ± 7.91	0.140 (0.889)
Nest concealment (%)	89.40 ± 1.05	68.00 ± 0.93	11.938 (0.001)*
Distance to water (m)	137.20 ± 39.03	108.06 ± 18.53	0.730 (0.467)
Distance to trek path (m)	19.69 ± 6.03	30.04 ± 9.44	-0.589 (0.557)
Distance to adjacent tree (m)	1.61 ± 0.16	1.56 ± 0.08	0.266 (0.791)
Distance to adjacent shrub (m)	0.88 ± 0.15	0.95 ± 0.07	-0.454 (0.650)

*significant values

Shown are means ± SE of untransformed variables and results of *t*-tests.

CONCLUSION

The Yellow-browed Bulbuls followed the general pattern of life history traits of other high altitude species, but they had a longer breeding season, heterogeneity in nest plant and site selection similar to that of low-altitude bulbuls. The role of habitat attributes, other than nest concealment, is not clear from the study. More information on growth rates, parental care patterns, nest predators and their behaviour, and nest success rates in disturbed habitats would help to understand the geographic diversity of avian reproductive traits and variation in the life history patterns in the tropical-temperate systems.

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DIVERSITY OF SPIDERS IN GROUNDNUT CROP FIELDS IN VILLAGE AREA OF SAURASHTRA REGION

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An ecological study was carried out to determine the quantitative and qualitative community structure and population of spiders in Groundnut (*Arachis hypogaea* Linn.) crop fields. Spiders were collected at random following a quadrat method (each quadrat of 1 sq. m taken per visit, total count 25 quadrats), 25 visits every week, during the crop season from July to November, 2002, at Munjka village of Rajkot, Gujarat State. A total of 809 spiders, belonging to 37 species under 22 genera and 10 families were collected. They were classified into three guilds based on their predatory behaviour as hunting, ambushing and web building; the per cent of spiders within active groups was 68.48, 14.83, and 16.69 respectively. The largest numbers of individuals collected belonged to the families Salticidae (27.69%), Lycosidae (24.23%), Oxyopidae (11.25%), and Philodromidae (11.13%). The most abundant genera were *Marpissa*, *Pardosa*, *Oxyopes* and *Theridion*. The most abundant salticid and lycosid identified to species were *Plexippus paykulli* (Audouin) (4.94%) and *Pardosa pseudoannulata* (Bosenberg and Strand) (4.94%) respectively. Maximum density of spiders was observed during the flowering stage of the crop in September, thereafter it decreased, and evenness index (e) was almost higher (3.0) in Groundnut crop-ecosystem. The results indicated that an increased diversity index (H') was correlated with crop growth and it ranked as October - 3.94 > September - 3.89 > August - 2.73 >Nov - 0.99 > July - 0.0.

Key words: Spiders, diversity, index (H'), groundnut, crop stages

INTRODUCTION

Spiders serve as biocontrol agents (CIKS 2002). The role of spiders in the biogenesis of different agro-ecosystems has been studied by Doane and Dondale (1979). Spiders form one of the most ubiquitous groups of predaceous organisms in the animal kingdom (Riechert and Lockley 1984). They are predators of thrips, insect larvae, aphids, plant bugs, leaf hoppers, and flies as reported by Nyffeler and Benz (1980). This study reports the predatory activities, species composition, density, relative density, richness (d), evenness index (e) and species diversity (H') of the spiders in groundnut (*Arachis hypogaea* Linn.) in relation to the crop growth stages.

METHODS AND STUDY AREA

The study was carried out during July to November 2002 in a groundnut field at Munjka village, near Saurashtra University Campus, Rajkot (22° 34' N; 70° 53' E; 138 m above msl). The climate is tropical arid to semiarid with three distinct seasons: monsoon, winter and summer. Rainfall is erratic, annual rainfall during 2002 was 385 mm. Groundnut - G-4 (hybrid variety) was sown in a 7,082 sq. m area of Black cotton soil. The crop was irrigated once by river water. The *kharif* (autumn) crop is usually sown in July in Saurashtra and the vegetative phase is complete by early September. The reproductive phase lasts until mid-October and the crop is harvested during November. A single dose of insecticide was sprayed during the reproductive phase of the crop (25 mg Parphate (Acephate 75% S.P.127 powder) and 10 ml Monocrotophos 36% S.L. mixed in 15*l* water).

Collections were made once a week, a total of 25 visits using the quadrat method (each quadrat of 1m × 1m per visit). Invented spiders were caught by bare handpicking (0700 to 0900 hrs; 1600 to 1800 hrs) at random and by pitfall traps (one pitfall per quadrat) completed both method under total 25 quadrats. The spiders were then preserved in 70% ethyl alcohol in plastic tubes. Identifications were done using Tikader and Malhotra (1980), Tikader and Biswas (1981), Tikader (1982), Pocock (1985), Majumder and Tikader (1991), and Gajbe (1999). Unidentified new species were considered up to genus level. Systematics was updated by Siliwal and Molur (2007).

The following formulae were used for quantitative analysis:

- Spider density = Total number of Individuals / Total number of quadrats
- Relative density = Spider density for a given month / Sum of spider densities over collection period x 100
- Familial percentage of species = (Number of species from a given family / Total number of species collected from all families) x 100

Ecological indices for qualitative analysis:

- Shannon Weiner Index (1948) of spider species diversity

$$H' \approx 3.321928/N \; (N \log_{10} N - \Sigma n_i \log_{10} n_i)$$

where, N is the total number of specimens and n_i the total number of species

- Species richness (d) as per Margalof (1958)

$d = (S-1) / \log N$

where, S = total number of species for a given month, N = number of total individuals for a given month

- Evenness index (e) as per Pielou (1966)

$e = H' / \log S$

where, S = total number of species for a given month, H' = Shannon Weiner diversity index

Table 1: Distribution of Spiders by Predatory Groups in Groundnut fields

S.No.	Spider Species	Total Occurrence of Spiders					
		No. of Spiders	%	No. of Males	%	No. of Females	%
A	**HUNTING GROUP**	554	68.48	118	72.84	436	67.39
I	**Lycosidae** Sundevall, 1833	196	24.23	21	12.96	175	27.05
1	*Evippa pralongipes* (Cambridge)*	4	00.49	–	–	4	00.62
2	*E. rajasthaneus* sp. nov.*	4	00.49	2	01.24	2	00.31
3	*Evippa* sp. Simon	32	03.96	–	–	32(11^S,19^J,**1^A**,**1^S**)	04.95
4	*Hippasa* sp. Simon	1	00.12	–	–	1^J	00.16
5	*Lycosa tista* Tikader*	22	02.72	–	–	22(2^S)	03.40
6	*L. madani* Pocock	5	00.62	–	–	5(1^S)	00.77
7	*Lycosa* sp. Latreille	19	02.35	–	–	19^J	02.94
8	*Pardosa birmanica* Simon*	30	03.71	–	–	30(1^S)	04.64
9	*P. pseudoannulata* (Bosenberg & Strand)	40	04.94	19(2^S)	11.73	21(2^S)	03.25
10	*Pardosa* sp. Koch	39	04.82	–	–	39(30^J, **9^S**)	06.03
II	**Clubionidae** Wagner, 1887	4	00.49	–	–	4	00.62
11	*Clubiona* sp. Latreille	4	00.49	–	–	4^J	00.62
III	**Salticidae** Blackwall, 1841	224	27.69	49	30.25	175	27.05
12	*Marpissa bengalensis* Tikader	16	01.98	–	–	16	02.47
13	*Marpissa* sp. Koch	91	11.25	15^J	09.26	76(74^J, **2^A**)	11.75
14	*Phidippus* sp. Koch	2	00.25	–	–	**2^A**	00.31
15	*Phlegra dhakuriensis* (Tikader)	17	02.10	–	–	17	02.63
16	*Plexippus paykulli* (Audouin)*	40	04.94	20	12.35	20	03.09
17	*Rhene* sp. Thorell	4	00.49	–	–	4^J	00.62
18	*Telamonia dimidiata* (Simon)*	14	01.73	14	08.64	–	–
19	*Telamonia* sp. Thorell	40	04.94	–	–	40(32^J, 8^S)	06.18
IV	**Oxyopidae** Thorell, 1870	91	11.25	30	18.52	61	09.43
20	*Oxyopes shweta* Tikader*	12	01.48	4	02.47	8	01.24
21	*Oxyopes* sp. Latreille	79	09.77	26^J	16.05	53^J	08.19
V	**Miturgidae** Simon, 1885	29	03.59	18	11.11	11	01.70
22	*Cheiracanthium poonensis* sp. nov.	8	00.99	8	04.94	–	–
23	*Cheiracanthium* sp. Koch	21	02.60	10^S	06.17	11^J	01.70
VI	**Sparassidae** Bertkau, 1872	10	01.24	–	–	10	01.55
24	*Heteropoda* sp. Latreille	8	00.99	–	–	8(6^J, **2^A**)	01.24
25	*Olios* sp. Walckenaer	2	00.25	–	–	2^J	00.31
B	**AMBUSHING GROUP**	120	14.83	20	12.35	100	15.46
VII	**Thomisidae** Sundevall, 1833	30	03.71	–	–	30	04.64
26	*Thomisus pugilis* Stoliczka*	3	00.37	–	–	3	00.46
27	*T. dhakuriensis* Tikader	1	00.12	–	–	1	00.16
28	*Thomisus* sp. Walckenaer	26	03.21	–	–	26^J	04.02
VIII	**Philodromidae** Thorell, 1870	90	11.13	20	12.35	70	10.82
29	*Tibellus poonaensis* Tikader	2	00.25	–	–	2	00.31
30	*Tibellus* sp. Simon	20	02.47	10^J	06.17	10^J	01.55
31	*Thanatus dhakuriensis* Tikader	32	03.96	10	06.17	22	03.40
32	*Philodromus* sp. Walckenaer	36	04.45	–	–	36^J	05.56

Table 1: Distribution of Spiders by Predatory Groups in Groundnut fields (*contd.*)

S.No.	Spider Species	Total Occurrence of Spiders					
		No. of Spiders	%	No. of Males	%	No. of Females	%
C	**WEB BUILDING GROUP**	135	16.69	24	14.82	111	17.16
IX	**Theridiidae** Sundevall, 1833	75	09.27	14	08.64	61	09.43
33	*Theridion manjithar* Tikader*	20	02.47	–	–	20	03.09
34	*Theridion* sp. Walckenaer	55	06.80	14(4^{S}, 10^{J})	08.64	41(4^{S}, 37^{J})	06.34
X	**Araneidae** Simon, 1895	60	07.42	10	06.17	50	07.73
35	*Araneus* sp. Clerck	1	00.12	–	–	$\mathbf{1}^{S}$	00.16
36	*Neoscona sinhagadensis* Tikader	20	02.47	–	–	20	03.09
37	*Neoscona* sp. Simon	39	04.82	10^{J}	06.17	29(28^{J}, $\mathbf{1}^{A}$)	04.48
	Total number of Specimens	809		162		647	
	Total number of Species	37					
	Total number of Genera	22					

Note: Asterisk (*) indicates common spider species reported by Patel and Pillai (1988); Non-bold alphabets and numericals in parentheses indicate specific age status for a given group of spiders;
Bold numericals indicate unidentified species.
Abbreviations: A - adult; S - subadult; J - juvenile

RESULTS AND DISCUSSION

Out of 809 specimens, 37 species belonging to 22 genera and 10 families were identified (Table 1). About 57.23% of the population were juveniles, 5.56% were subadults, 34.86% were adults and 2.35% adults and subadults of unidentified new species. The spiders were classified according to their predatory behaviour following Satpathi (2004). (i) Hunting spiders with 25 species (68.48%) belonging to Lycosidae, Clubionidae, Salticidae, Oxyopidae, Miturgidae and Sparassidae; (ii) Ambushing spiders with 7 species (14.83%) of Thomisidae and Philodromidae, and (iii) Web building spiders comprising 5 species (16.69%) of Theridiidae and Araneidae. The numerically dominant family and genus rank are summarised in Table 2.

Hunting Group

(i) **Lycosidae** – is the second most dominant family in available spiders and species-wise stands on first position. Members of this group were present during all the growth stages of groundnut, represented by 10 species from 4 genera; and two unidentified species one each of genus *Evippa* and *Pardosa* (Table 1). Genus *Evippa*, *Lycosa*, and *Pardosa* were common, while *Hippasa* was found rarely. Throughout the crop season (July-November), juveniles and subadults were found in almost equal proportion to the adults. Females were more abundant than males by a ratio of 8:1 among Lycosids. Females with cocoons were found during the reproductive phase of the crop from mid-September to November. Of all spiders identified to species, *Pardosa pseudoannulata* (Bosenberg and Strand) and *Plexippus paykulli* (Audouin) of Salticids were the most abundant, followed by *Pardosa birmanica* Simon and *Lycosa tista* Tikader respectively (Table 1). Adult females and males of *Evippa rajasthaneus* were collected only during late November.

(ii) **Clubionidae** – Clubionids (0.49%) was the tenth most abundant family caught with only juvenile females of a single species collected during the reproductive stage of the crop (mid-September to mid-October).

(iii) **Salticidae** – is one of the most dominant family represented by eight species from six genera, and two unidentified species, found during almost the entire crop season from August to October. Adult females of *Phlegra dhakuriensis* (Tikader) (2.6% of total females collected) and *Marpissa bengalensis* Tikader (2.5%) were collected in September and October, respectively; adult males of *Telamonia dimidiata* (Simon) (8.64%) were also collected in September. Other Salticid species of both sexes were found in good numbers during late August to October. Juveniles of the genera *Marpissa* and *Telamonia* were more numerous during the vegetative stage of the crop (late August to early September). During flowering and early pod forming stage of crop (mid-September to mid-October), more adult males and females were caught. During August-September fewer females than males were observed, while females dominated in October only. *Rhene* sp. was found the least (0.49% of total spiders collected); whereas *Marpissa* sp. (11.25%), *Telamonia* sp. (4.94%) and *Plexippus paykulli* (Audouin) (4.94%) were caught frequently.

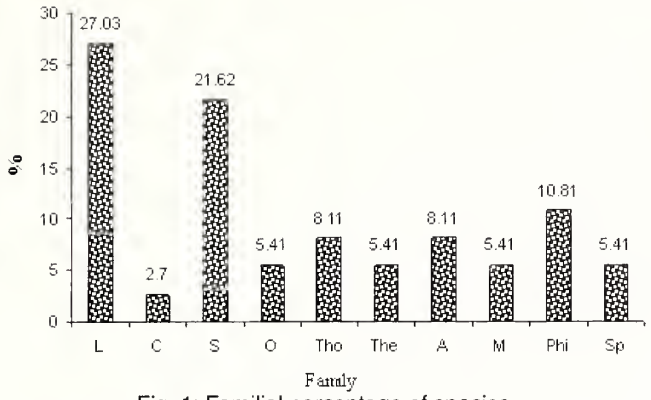

Fig. 1: Familial percentage of species

Abbreviations: L - Lycosidae, C - Clubionidae, S - Salticidae, O - Oxyopidae, Tho - Thomisidae, The - Theridiidae, A - Aranidae, M - Miturgidae, Ph - Philodromidae, Sp - Sparassidae

(iv) **Oxyopidae** – All Oxyopids were found during the late vegetative and early reproductive stage of the crop (late September-mid October). Peak abundance of adults was reached from early to mid-October. Males of *Oxyopes shweta* Tikader (2.47%) were seen on the upper parts of the plants during early October. The number of juvenile females increased considerably by late September - mid October. The number of female Oxyopids (i.e., 61/30) exceeded the number of males by a ratio of 2:1.

(v) **Miturgidae** – Members of this family have been reported to be important as pest-control agents in the agricultural sector (Sewlal and Cutler 2003). Two species of *Cheiracanthium* (3.59%) were recorded to be most abundant during the reproductive phase of the crop (late September-October). Adult males of *Cheiracanthium poonensis* (4.94%) were observed only during October. Subadult males and juvenile females of *Cheiracanthium* sp. Koch were observed from late September to October.

(vi) **Sparassidae** – These giant crab-spiders were the ninth most abundant family observed running over plants and hiding under dead leaves in only October. The adult and immature females represent 2 species, 2 genera and 2 unidentified adult spiders of *Heteropoda* sp. Latreille and juvenile females of *Olios* sp. Walckenaer, were caught in early October.

Ambushing Group

(i) **Thomisidae** – Three species of *Thomisus* (3.7%) were caught during the flowering and pod forming stage of crop during mid to late October with only female spiders. They were found moving over the terminal buds and flowers.

Thomisus is the eleventh most abundant genus (Table 2). An adult female *Thomisus dhakuriensis* Tikader was collected in late October.

(ii) **Philodromidae** – Members of this fast runner family were represented by 4 species and 3 genera. They were caught in vegetative to mid-reproductive stage of the crop (mid-August to mid-October). The female to male ratio of this family was 3.5:1. The adult and juvenile spiders of *Thanatus dhakuriensis* Tikader and *Philodromus* sp. Walckenaer respectively were most abundant (almost three times more of all philodromids) in only September. The adult male and female spiders of genus *Thanatus* were collected in August and October respectively. *Thanatus dhakuriensis* Tikader was the second most abundant spider species (Table 1).

Web Building Group

(i) **Theridiidae** – This was the fifth most abundant family, represented by 2 species of *Theridion* (Table 1). Theridiids were observed during the late vegetative to flowering stage of the crop (September and October). The female to male ratio of this family was 4.4:1. All subadults and juveniles of *Theridion* sp. were found in October only.

(ii) **Araneidae** – This group included 3 species from 2 genera and two unidentified species of the genera *Neoscona* and *Araneus*. *Neoscona sinhagadensis* Tikader (2.47%) and *Neoscona* sp. (4.82%) were most abundant during the flowering stage of the crop (late September to October). The subadult female of *Araneus* sp. was caught in mid-October. The female to male ratio in this family is 5:1.

Table 2: Family and Genus rank in available spiders of groundnut field

Family Rank	Family	Genus	Group Rank
1	Salticidae	*Marpissa*	2
		Phidippus	17
		Phlegra	14
		Plexippus	8
		Rhene	16
		Telamonia	6
2	Lycosidae	*Evippa*	8
		Hippasa	18
		Lycosa	7
		Pardosa	1
3	Oxyopidae	*Oxyopes*	3
4	Philodromidae	*Tibellus*	13
		Thanatus	10
		Philodromus	9
5	Theridiidae	*Theridion*	4
6	Araneidae	*Neoscona*	5
		Araneus	18
7	Thomisidae	*Thomisus*	11
8	Miturgidae	*Cheiracanthium*	12
9	Sparassidae	*Heteropoda*	15
		Olios	17
10	Clubionidae	*Clubiona*	15

Table 3: Spider density, relative density, species diversity (H'), species richness (d) and evenness index (e) in relation to growth period of groundnut crop

Month	No. of quadrats	No. of individuals	No. of species	Species Density-D (no. of individuals/m²)	Relative Density-RD (%)	Diversity Index (H')	Species Richness (d)	Evenness Index (e)
July	02	08	1	4	3.05	0	0	0
August	05	138	8	28	21.4	2.73	3.27	3.02
September	05	298	20	60	45.8	3.89	7.68	2.99
October	10	356	23	36	27.5	3.94	8.62	2.89
November	03	09	2	3	2.3	0.99	1.05	3.29
Total	25	809		131				

The status of females and males among predatory groups was analyzed (Table 1). It revealed that the percentage of female spiders (78.7%) was nearly four times higher than for males (21.3%) within all hunters. The other two groups, i.e. Ambushing (females - 83.3%) and web building (females - 82.2%), showed very close female to male ratios of about 5:1. Hunting (68.5%) spiders formed the most abundant group while the ambushing group of spiders was least numerous in the groundnut field. An analysis of age status for males and females revealed that the percentage of juveniles was 57.23% that of subadults was 5.56%, that of adults was 34.86% and that of unidentified new species was 2.35%. A high percentage of juveniles reveal that (1) ecological factors like humidity, temperature, edaphic factor, food availability etc. and their relation to physiological activities (Barghusen *et al.* 1997) of spider as food and feeding, breeding were maintained at such kind of habitat (2) predominant juveniles were of monsoon breeding families like Lycosidae, Salticidae, Clubionidae, Oxyopidae etc. (3) prolong vegetative and reproductive phase of the crop and constant irrigation provide increased insect food sources.

Assessments in relation to Crop Growth

Out of 809 specimens, a total of 8 individuals from one species of *Pardosa* sp. Koch were collected during July, 138 specimens of 8 species during August, 298 specimens of 20 species during September and 356 specimens of 23 species during October. Only 9 specimens of 2 species were collected during late November in three visits (Table 3). The catch was very poor after the crop was harvested. This data supports the results of Patel and Pillai (1988) with some similar species in the same crop. The spider density was highest during September (60 individuals /sq. m); it dropped to 36 individuals /sq. m in October. The dominant species during September included *Marpissa* sp., *Philodromus* sp., *Neoscona* sp., *Oxyopes* sp., *Lycosa tista*, and *Tibellus* sp. The relative density was therefore also highest during September (45.8%). The species composition changed with the growth period of the crop and the species diversity (H') decreased according to the following trend: October (3.94) > September (3.89) > August (2.73) > November (0.99) > July (0.0). Spider species richness (d) followed a similar trend with the growth period of the groundnut crop as shown in Table 3. This supports the hypothesis of Pianka (1966) that as the crop growth increases the prey availability allows more species to co-exist. The evenness index of the spider species was almost high (e = 3.0) during groundnut crop growth phase. This supports the statement of Pielou (1966) that the evenly distribution of spiders increases with decreases in stress; as the most of value is higher from zero during entire crop growth phase. The familial percentage of species for the families Lycosidae (27.03%), Salticidae (21.62%), and Philodromidae (10.81%) were especially high (Fig. 1). Out of 809 spiders, 647 were females (79.98%) and 162 were males (20.02%) with a sex ratio of 4:1. Generally, the male dies after mating and the female dies in winter after laying several hundred eggs.

In similar studies, at different locations in Gujarat, dominant families observed were Theridiidae (18.96%), Lycosidae (17.90%), Salticidae (12.32%), Clubionidae (10.06%) and Thomisidae (8.51%) (Patel and Pillai 1988). Differences may be due to ecological variations like temperature, humidity, and edaphic factors. Moreover, this may reflect physiological activity of spiders. Spiders are exothermic animals both their metabolic rate and their activity levels vary with temperature and humidity as stated by Barghusen *et al.* (1997).

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DISCOVERY OF A BREEDING GROUND OF THE GREATER ADJUTANT *LEPTOPTILOS DUBIUS* AND THEIR CONSERVATION IN THE FLOODPLAINS OF BIHAR, INDIA

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A new breeding population of the Greater Adjutant has been discovered in Bihar in the Ganga and Kosi river floodplains (*diara*) in 2006-07. Earlier its breeding was reported only from Cambodia and Assam (India). This breeding population was found almost restricted to a single colony in the Important Bird Area, Kursela river course and floodpain (*diara*). First site was at Ganga *diara* (25° 15.142' N; 86° 48.480' E) in Bhagalpur district, where two nests were located on a single tree in October 2006. We surveyed nine districts of the state, mostly north to the Ganga river up to the border of Nepal. Sixteen nests were found in Kosi *diara* on four trees by the end of January 2007, where the Greater Adjutant had successfully bred. In 2007-08, of the 35 nests recorded on 10 nesting trees, 9 in the Kosi *diara* and 1 in Ganga *diara*, 32 nests were successful.

The conservation efforts and surveys continued for two successive seasons, i.e., 2006-2007 and 2007-2008. In 2006-2007, 25 juveniles and in 2007-2008, 64 juveniles fledged from the nests, of which 8 were from Ganga *diara*, and 56 were from Kosi *diara*. Globally, the population of this rare Stork is declining, whereas in Bihar its population has shown a remarkable increasing trend in recent years.

Key words: Greater Adjutant, *Leptoptilos dubius*, new breeding ground, conservation, increasing population trend

INTRODUCTION

The Greater Adjutant *Leptoptilos dubius* is probably the rarest and most endangered stork in the world; categorized in the Red list of IUCN (2008) as Endangered. The recent estimate of its total population is 650-800 individuals (Wetlands International 2006). It was known to breed only in Cambodia and Assam (India). Once abundant in many Asian countries, till the beginning of twentieth century, it has become rare or extinct from most of its past distribution range, and is now confined to the Brahmaputra Valley of Assam, India (Saikia and Bhattacharjee 1989; Rahmani *et al.* 1990), with a small breeding population of 100-150 in Cambodia (Mundkur *et al.* 1995). The recently discovered population of Greater Adjutant in Bihar has probably not been considered while estimating the total world population. Presently, this endangered species has been placed under schedule IV of Wildlife (Protection) Act, 1972, Amendment Act, 2006 (39 of 2006).

After the discovery of a few nests of the Greater Adjutant, we approached the Wildlife Trust of India (WTI) who supported us with a Rapid Action Project (RAP) under their Wild Aid Program for the protection of the breeding colony.

The prime objective of this project was to provide direct protection to the Greater Adjutant from any disturbance in their breeding ground, hunting by Banpar – a nomadic hunting tribe locally known as 'Gulgulwa', protection of nesting trees, reducing the chance of mortality of chicks due to accidental fall, locating other nesting sites in the adjoining area, spreading awareness among the locals and taking advocacy measures for the protection of the species and their habitat.

Background

Since the beginning of this century, the Greater Adjutant was being regularly reported foraging in and around the river course of Ganga in the Bhagalpur district, Bihar. Some old records exist from north Bihar, i.e., one in July 1901 from Darbhanga (Inglis 1904), one in April 1988, from Purnea (Rahmani *et al.* 1990), eight in March 1981, from Kishanganj (N. Krabbe pers. comm. in 1985), and six in April 1988, from Kursela (Rahmani *et al.* 1990). The best survey count of 53 individuals of this species was recorded in Vikramshila Gangetic Dolphin Sanctuary, Bhagalpur in May, 2006 (Choudhary and Mishra 2006). This was indicative of a breeding population somewhere nearby. The breeding of Lesser Adjutant *Leptoptilos javanicus* (LA) was also reported for the first time in Bihar in 2004 (Mishra *et al.* 2004, 2006). This was also suggesting the possibility of finding the breeding of Greater Adjutant in this area.

STUDY AREA

An extensive survey was conducted from mid March to end April 2007, in the nine north-eastern districts of Bihar, namely Bhagalpur, Khagaria, Katihar, Purnea, Madhepura,

Saharsa, Supaul, Araria and Kishanganj in an area between 25° 15.141'-26° 31.646' N and 86° 08.345' -88° 09.165' E, extending up to the border of Nepal in the north and Bangladesh in the east.

Though, the main breeding colony of Greater Adjutant was found at Kadwa *diara* Panchayat in the Kosi river floodplains, adjacent areas like Khairpur Panchayat, Dholbajja and Chausa also seemed to be potential breeding sites.

Ganga *diara*

In Ganga *diara*, the nests of Greater Adjutant were first located in 2006 at Naya *tola* Basa of Motichak near Sultanganj in the district of Bhagalpur (25° 15.142' N; 86°48.480' E). In 2007, the nests of Greater Adjutant were built in Madhopur-Manharpur villages, about 18 km north-west to Bhagalpur (25° 15.765' N; 86° 51.406' E).

These sites are a little away from the road and less frequented by people. But the farmers have their settlements for agricultural and dairy purpose here. The area remains inundated during the monsoon but in the remaining months, the main crops cultivated are maize, wheat, pulses, oil yielding seeds, and potato. *Parthanium hysterophorus* and *Cannabis sativa* are the major problematic weeds in the cultivating fields. Some bamboos and trees, such as *Acacia nilotica*, *Bombax ceiba*, and *Ficus religiosa* are found scattered in the crop fields, but there were no bamboos under the tree where birds were found breeding. People were found helpful in protecting these birds.

Kosi *diara*

According to villagers, the Greater Adjutant have been found breeding in the Kadwa Kosi *diara*, north to the Kosi river since the last 10-15 years while some report their breeding since the last 25 years. They are breeding here in different *tolas* (villages), namely Kasimpur, Ashram *tola*, Lakhminia, Khairpur, Pratapnagar in the Bhagalpur district, and Khalifa *tola*, in the Madhepura district, at the border of Bhagalpur district.

These sites are at an aerial distance of about 23 km north-east of Bhagalpur and about 28 km north-east from the Ganga *diara* breeding sites on the northern-most boundary of Bhagalpur district at the border of Madhepura.

The area is under agriculture and some large trees, such as *Ficus religiosa*, *Bombax ceiba*, *Ficus infectoria*, *Ficus bengalensis*, *Syzigium cumini*, *Gmelina arborea*, *Dalbergia sisso*, *Ficus glomerulata*, *Acacia nilotica*, and *Terminalia arjuna* were observed in the area. There are orchards of *Mangifera indica* and *Litchi chinensis* at a few places. The orchards of *Bombax ceiba* are grown for commercial purposes. Bamboo is commonly grown for commercial as well as for household purposes. The main crops of the area are maize, wheat, pulses, oil yielding seeds and potato. The area is affected by flood almost every year. However, the land is not eroded by flood water as is the common character elsewhere in flood affected areas, where rivers and water channels change their course frequently. The villages are devoid of electricity, telephone lines and other basic facilities and the area is not easily accessible.

The Greater Adjutant was seen breeding on trees in the middle of the cultivating fields and also in the courtyard of village houses.

METHODOLOGY

The surveys were accomplished using four wheelers, two wheelers and boats, but at times we walked on foot where approach was inaccessible by any vehicle. The settlements of Banpar, a nomadic hunting tribe, were also identified.

Locals were appointed at both Ganga and Kosi *diara* to observe the birds and report to us. They were provided mobile phone, binocular, camera and data collection sheets to note observations. Safety nets, made of thick nylon lined with soft muslin cloth were placed under a few trees initially to protect the hatchlings/chicks/fledglings from casualty in case they fell from the nest. This measure had been effective in protecting the chicks of Greater Adjutant in Assam, where the fallen chicks were relocated to the nests. In case of rejection by the parents, the chicks were hand-reared. The only option available was the local village veterinary doctor, who could provide immediate medical care to the chicks during emergency. The forest officials at local and state level, and zoo authorities at Patna, were contacted to provide the transport and medical facilities to the injured birds.

Placing of safety nets did not prove much useful in this case as falling of nests was not common, also it did not protect the falling chicks where bamboo grew under the trees.

For creating awareness, village meetings were arranged in the breeding and foraging grounds of the Greater and Lesser adjutants, signage were erected and pamphlets were distributed. The villagers, local leaders of *gram panchayat* (village council), teachers, school students, village elders, local political workers and police officers were also involved in the meetings to support the awareness programmes. The print and electronic media were contacted to add value to our conservation efforts. As a conservation measure, the adjutants were linked with religious beliefs, epics, spirit and mythology.

OBSERVATIONS

During our regular bird watching trips, two pairs of

Table 1: Ganga *diara* (Flood Plains) Site 2007-2008

Place	Location	Tree	No. of Nests	No. of Chicks / Juvenile
Manharpur - Madhopur (Dist: Bhagalpur) 25° 15.765'N and 86°51.406'E	South of Ganga River	Peepal tree (*Ficus religiosa*)	4 nests of GA and 3 nests of LA on the same tree	Chicks / juveniles of GA (3+1+2+2)

Greater Adjutant were observed building nests on *Bombax ceiba* in October 2006, in the Ganga *diara* at Naya *tola*, Motichak in the Bhagalpur district; there were seven nests of Lesser Adjutant on the same tree. The Greater Adjutant had build nests here for the first time, while the Lesser Adjutants are known to breed since 7-8 years. This is the first report of Greater Adjutant nesting outside Cambodia and Assam (India) in 50-60 years. But in January, both the nests were dismantled due to unknown reasons. Only some broken pieces of fresh egg shells were found under the tree with some yolk.

Subsequently, nine districts of the state were explored, and a new breeding colony of Greater Adjutant was discovered in the Kosi Kadwa *diara* with 16 nests recorded by end January 2007 (Table 2). The nests were protected by appointing watchers, placing safety nets under the trees and spreading awareness. Twenty-five chicks fledged successfully from the Kosi Kadwa *diara* by end May 2007.

During 2007-2008, no nest of Greater Adjutant or Lesser Adjutant was build at the old site on *Bombax ceiba* at Motichak in Ganga *diara*. They had visited this tree in August 2007, but did not attempt to build a nest as a troop of Hanuman Langur had stayed on this tree for two days and scared all the Adjutants. There seemed to be no other disturbance at this breeding site, other than that by Langurs as reported by the local people.

In October 2007, Lesser Adjutant were found about one km south-east from the original site, while Greater Adjutant had shifted about 6-7 km south-east to Madhopur-Manharpur villages (Table 1). Both Lesser Adjutant and Greater Adjutant had arrived at this site for the first time for breeding. According to the locals, Lesser Adjutant had arrived since July, while the Greater Adjutant followed a little later.

The Greater Adjutant generally breeds in colonies. At a site in Ganga *diara*, we recorded four nests on a huge *Ficus religiosa* along with three nests of the Lesser Adjutant on the same tree. Altogether, seven nests were found, in addition to one incomplete nest on the tree. All the four nests were successful and by the end of third week of April 2008, eight juveniles fledged. This appears to be first successful breeding record of the Greater Adjutant in the Ganga *diara*.

In December 2007, 31 nests were recorded in the Kosi *diara*. Three were dismantled later for unknown reasons, and out of remaining 28 nests, 56 chicks fledged.

With further support from the Rapid Action Project of the Wildlife Trust of India, conservation measures were taken from March 2007 to May 2008 to protect these breeding birds in both Kosi and Ganga *diara*. The impact of awareness undertaken in 2006-07 was seen in 2007-08. From 32 successful nests, 64 chicks (Table 3) had hatched, but 61 ultimately survived (Table 4). This when compared to 18 nests built in 2006-2007, 16 were successful and 25 juveniles were added to the Greater Adjutant population in Bihar.

The Greater Adjutant has been reported breeding in Kadwa Kosi *diara* since the last 10-15 years, but their population has not increased much during this period. This was probably due to the number of threats the birds were facing, and because the locals were not aware about the importance of this highly endangered species.

For the last two years, the Greater Adjutants build nests in the Ganga *diara*. This is certainly a positive sign for the Greater Adjutant as they have extended their breeding range to Ganga *diara* after establishing their colony at Kosi *diara*.

Table 2: Kosi *diara* (Flood Plains) Sites 2006-2007

Place	Trees	No. of nests	No. of Chicks/Juvenile
Kasimpur (25° 27.366'N, 87°02.656'E)	Peepal tree (*Ficus religiosa*)	6 nests of GA	Chicks / juveniles of GA -12 (2+2+2+2+2+2)
Ashram *tola* (25° 27.687'N, 87°03.472'E)	Pakad (*Ficus nitida*)	7 nests of GA (1 dismantled, 1 abandoned)	Chicks / juveniles of GA-7+ (1 died) 1+1+2+1+2)
Lakhminia (25° 27.755'N, 87°03.698'E)	Gambhar (*Gmelina arborea*)	1 nest of GA	Chicks / juveniles of GA-2
Lakhminia (25° 27.760'N, 87°03.688'E)	Peepal tree (*Ficus religiosa*)	2 nest of GA	Chicks / juveniles of GA-4 (2+2)

Table 3: The details of different sites of Kosi *diara* in the 2007-08

Place	Trees	No. of nests	No. of Chicks/Juvenile
Kasimpur (25° 27.366'N, 87° 02.656'E)	Peepal tree (*Ficus religiosa*)	4 nests of GA	Chicks / juveniles of GA-8 (3+1+2+2)
Kasimpur (25° 27.390'N, 87° 02.465'E)	Kadamb (*Anthocephalus cadamba*)	1 nest of GA	Chicks / juveniles of GA-2
Kasimpur (25° 27.238'N, 87° 02.485'E)	Semul (*Bombax malabarica*)	2 nests of GA and 2 nests of LA	Chicks / juveniles of GA-2 (1+1)
Ashram *tola* (25° 27.687'N and 87° 03.472'E)	Pakad (*Ficus nitida*)	3 nests of GA (3 other dismantled)	Chicks / juveniles of GA-8 3+2+2+1 (without nest)
Lakhminia (25° 27.755'N, 87° 03.698'E)	Gambhar (*Gmelina arborea*)	1 nest of GA	Chicks / juveniles of GA-2
Lakhminia (25° 27.760' N, 87° 03.688'E)	Peepal tree (*Ficus religiosa*)	11 nest of GA	Chicks / juveniles of GA-23 (3+2+2+2+2+2 +2+2+2+2+2)
Khairpur (25° 27.819'N, 87° 03.312'E)	Peepal tree (*Ficus religiosa*)	2 nest of GA	Chicks / juveniles of GA-3 (2+1)
Khalifa *tola* (25° 28.481'N, 87° 03.162'E)	Peepal tree (*Ficus religiosa*)	1 nest of GA	Chicks / juveniles of GA-2
Pratapnagar (25° 26.367'N, 87° 03.209'E)	Kahwa (*Terminalia arjuna*)	3 Nests of GA	Chicks/ juveniles of GA-6 (2+2+2)

The tree owners were annoyed with the breeding Greater Adjutant as they littered the ground and excreted on their cattle causing wounds. On the other hand, children were seen collecting fish dropped by the parent bird while feeding its juveniles.

The detail accounts of different sites of Ganga and Kosi *diaras* are shown in the Tables.

Threats in the breeding ground

Some major threats to Greater Adjutant observed during our study were by Banpar, a nomadic hunting tribe that often steal eggs, and kill birds and their chicks. Felling and chopping the nesting trees, natural disaster like thunder storm, falling of nests and chicks, accidental trap of juveniles in fishing nets, lack of awareness among the people, annoyance caused to the villagers by breeding birds by littering the courtyard and excreting on the cattle, disturbance by the tree dwelling animals, such as Hanuman Langur and increasing population of nesting Lesser Adjutant in the breeding zone of Greater Adjutant, were some of the threats in the breeding ground.

Threats and efforts in the foraging ground

The Greater Adjutant remains at risk in its foraging ground, especially when juveniles come to feed. Some instances of their being trapped in the nets of fishermen have also been reported. On one such occasion, one juvenile was beaten to death with a bamboo pole by a fisherman in June 2007. Probably the young bird had gone in search of an easy catch from the fishing net.

A juvenile was caught in a village at Bhawanipur, Narayanpur while foraging in early May 2008. This was reported in a leading Hindi newspaper, *Dainik Jagran*. The children were playing with this bird while the villagers surrounded it out of curiosity. The area is well-known for bird trading on National Highway 31, especially ducks, waders, Bank Myna *Acridotheres ginginianus*. This place is

Table 4: Mortality of Greater Adjutant

	Nesting trees	Confirmed Mortality	Other Mortality Reported	Nests Fallen / Destroyed	Nests survived	Estimated mortality by falling of nest	Chicks Survived
2006-2007	5	4	5	3 + 4*	16	14	25
2007-2008	10	4	9	3	32	5	61

* - these 4 nests were destroyed by the locals

about 16 km north from the Ganga *diara* breeding site and about 25 km south-west from the Kosi *diara* site in aerial distance. With the help of policemen and a press reporter, the bird was rescued and released to join its flock again. Two days later, a juvenile was found dead in the crop field of Ganga *diara* in the same area. It seemed to have died about 10 days ago and had probably fallen prey to a predator.

Caring the injured chicks/Juveniles

In March 2007, a chick at Ashram *tola* had fallen from the tree on the ground and was badly injured in the head and neck region due to the bamboo spikes. A local veterinary doctor dressed the wounds with Savlon, an antiseptic solution. The chick seemed to be about a month old and weighed around 5.5 kg. At this stage (about 5 weeks) the chicks try to leap in the air (Singha *et al.* 2003) and fall from the nest. It was conscious and standing on its feet. Further, the chick had been injected with Dexona (a steroid) 1.5 ml, Neurobion (Vitamin) 1.75 ml and Penicillin (antibiotic) 1.25 ml. As no food was immediately available to feed the chick it was given a little Electral (ORS) powder which it regurgitated. Since we were new to the villagers, they were suspicious about our interest in Greater Adjutant. We therefore did not transport the chick to the city where some qualified veterinary could have treated him. We decided to relocate the chick back to the nest from which it had fallen. With the help of a gunny bag folded to half its length, the chick was relocated in its nest, where another one was already present. All the adults and juveniles (about 10-12) had left the tree during this process and had taken shelter on another tree about half a km away. They returned gradually after about half an hour. Unfortunately, the next day the chick had fallen again and was found lying dead on the ground. Probably the parents had rejected the injured chick.

On another occasion, in the first week of April 2008, due to a severe thunder storm and rain, two juveniles were seriously injured at Kasimpur. One died immediately while the other suffered a leg injury. This injured bird could not be traced for a couple of days and was later found in a maize field. We took assistance of the Divisional Forest Officer, Conservator of Forest, Chief Conservator of Forest, and zoo authorities at Patna to provide better treatment and facilities to this injured bird. But, before it could be transported to the zoo, the bird died. The juvenile was buried in the soil with salt, prior to which the wife of a local villager offered flowers, incense stick after taking a bath as it is done in the rituals of a human death. The people in the area have developed religious regard to these Adjutants as a result of our campaign. They believe that these birds called "Garud" are the carriers of Lord Vishnu.

Population Estimate

Fifty-three Greater Adjutants were seen foraging in the river course of Ganga in May 2006 and 25 individuals had fledged in 2006-07. During monsoon (July to September), such floodplains in the region are difficult to access, and thus we could not monitor these birds. It appears that there was a population of at least 78 individuals of Greater Adjutant existing in this part of Bihar in 2007.

During the season, 2007-2008, 35 nests were built (3 were dismantled) by Greater Adjutant in Kosi and Ganga *diara*. This confirms the presence of at least 70 (35 x 2) adults. We found 64 juveniles during our study. The number of adults and juveniles totals to 134 individuals. The 25 juveniles fledged last season may not have grown enough to breed. The Greater and Lesser adjutants become sexually mature at 3-4 years (Bhattacharjee and Saikia 1996). If we add that number, the total estimate suggests about 159 individuals in the state in 2008. Three died, thus the final estimate is 156 individuals of Greater Adjutant in Bihar. This newly discovered population in Bihar has probably not been considered while estimating the total global population of this species.

Nesting materials

The Greater Adjutant was observed using nesting materials from the trees of *Dalbergia sisso*, *Bambusa* sp., *Acacia nilotica*, *Pithecellobium dulce*, *Cannabis sativa*, *Solanum melangina*, *Parthenium hysterophorus*, *Sesbania* sp., *Saccarum munja*, *Croton* sp., *Ficus religiosa*, *Bombax ceiba*, *Gmelina arborea*, *Anthocephallus cadamba*, *Terminalia arjuna* and *Ficus infectoria*. During 2006-07, *Solanum melangina* twigs were found to be the major component of the nests built on *Bombax ceiba* at Naya *tola*, Motichak in Ganga *diara*. Later, these nests were dismantled in mid-way probably because it was weak in nature and could not sustain the weight and activities of the breeding Greater Adjutant.

Food

Fish was the main food of the breeding Greater Adjutants. They were also observed eating snakes, frogs, bats, crabs, and unidentified beetle-like insects. Undigested remains of these animals were found under the nesting trees. Two head portions of the fish *Wallago attu* were found lying under a nesting tree. Looking at the size of one of the heads, it was apparent that the fish would have weighed around 2-3 kg. Probably these large fishes were carried from a distance of a few kilometers. Rats are also taken by the adjutants, especially when ploughed fields are irrigated, the rats come out of their holes and are caught by the Greater Adjutants. In 2007, a Greater Adjutant was seen feeding on a dead cattle in the Kosi river.

Specific observations

In Bihar, single-species nesting colonies of Greater Adujtant were found. Only at two sites, the bird was found sharing a tree with the Lesser Adjutant. One was on *Ficus religiosa* at Ganga *diara*, and other on *Bombax ceiba* at Kosi *diara*, both in 2007-08.

Greater Adujtant have been reported to start nest building activities in September and leave the nesting trees by April or early May. At some places, people have reported the birds on potential nesting trees in August, a peak flood period.

Bats have been observed as food of the adjutants during this study. Interestingly, at Ashram *tola* in Kosi *diara*, about 25 bats were observed clinging to the branches of the breeding tree below the nests, while the juveniles and adults were present.

In 2007, the juveniles left nests by mid-May, whereas in 2008, they fledged in the third week of April, i.e., almost a month earlier. We do not know the reason for this difference in the fledging period.

DISCUSSION

The population estimate of 2008 suggests the presence of at least 156 Greater Adjutants in Bihar compared to a total of 78 in 2007. The present Greater Adujtant population in Bihar is similar to that found in Cambodia. Elsewhere, the population of this species is declining (IUCN 2008), whereas in Bihar this bird appears to show an increasing trend. However, we need data of many more years to conclude whether this increasing trend is due to better search efforts and public awareness (hence more reports), or due to real increase in the numbers.

In Assam also, the population of these is probably declining; incidences of falling nests are common (Bhattacharya pers. comm. in 2003). There may be a possibility that the population of Greater Adjutant is shifting from Assam to Bihar in search of suitable places to breed. If so, then why has West Bengal, the state between these two states, not reported any incidences of breeding of this bird? Possibly, the birds prefer the large river basins of Ganga and Kosi in Bihar after the Brahmaputra river system in Assam, and find the next suitable habitat at the confluence of Ganga and Kosi rivers at Kursela. Burhi Gandak river also confluences near this breeding zone, where sufficient food and suitable habitat is available. Very often Greater Adjutants are seen foraging in this area. Breeding is not being reported in West Bengal probably due to hunting pressure or lack of suitable breeding habitat.

In Kosi *diara*, in the nesting area of the Greater Adjutant, the number of breeding Lesser Adjutant is also increasing. Breeding population of Lesser Adjutants is spread over a large area in the state (Mishra *et al.* 2004; 2006), whereas, Greater Adjutant nesting is almost restricted to a pocket. During our survey in 2007, only 23 nests of Lesser Adjutants were recorded in Bhagalpur and Madhepura districts. But in 2008, we recorded 55 nests of Lesser Adjutant in the breeding area of the Greater Adjutant.

During 2006-07, not more than two chicks or juveniles were seen in any of the nest, whereas in 2007-08, three chicks / juveniles were recorded in four nests. Later, in 2008-09, a clutch of four chicks was observed in one of the nests at Kasimpur in Kosi Kadwa *diara*. In 2007-08, eleven nests were built on a single *Ficus religiosa* tree at Lakhminia from where 23 juveniles had fledged, whereas there were only two nests and four chicks in 2006-07 on this tree. This is possibly the result of elimination of some threat factors as a result of our campaigns during the last two seasons.

Congregation

Breeding storks flock at the beginning of the breeding season (Singha et al. 2003), but here a large flock of 53 Greater Adjutant in four groups of 10-15, were observed during the evening hours in the river course of the Ganga by end May in 2006 (Choudhary and Mishra 2006). It seems that the whole colony of Kadwa Kosi diara had congregated at this place just after the completion of their breeding season. This flock had both adults and juveniles. Probably such congregations take place both at the beginning and end of every breeding season. These periods may be the appropriate time to monitor population and understand colonial behaviour of the adjutants. After breeding, all the juveniles and adults leave their nests and the juveniles still tend to live in association with their parents. Therefore, we can see some large flocks.

Nests occupied by other bird species

In Kadwa Kosi *diara*, the Indian Black Ibis *Pseudibis papillosa* had occupied the partially destroyed nest of a Greater Adjutant on a *Ficus* tree at Kasimpur. At Lokmanpur, all the vacated nests of Lesser Adjutants on a Banyan tree were occupied by the Black Ibis. At both places high mortality of Black Ibis was recorded; crows were observed as the main predators, which destroyed their eggs and chicks.

The Black Kite *Milvus migrans govinda* was seen using the vacated nests of Lesser Adjutant and Black-necked Stork *Ephippiorhynchus asiaticus* in Ganga *diara* during our study. On one occasion, at Motichak in Ganga *diara*, after the departure of all Greater and Lesser adjutants, Black-headed Ibis *Threskiornis melanocephalus* were seen in fairly good numbers on the same tree, but they did not stay for long.

Hurdles and Constraints

The sites could not be monitored from the beginning of the breeding season. Also, the presence of the Greater Adjutant in the state could not be tracked during peak floods between July-August, due to inaccessibility and lack of resources.

Lack of treatment facilities for injured birds, bamboo growth under breeding trees, and difficult accessibility until January was our major constraint. The Pontoon bridge on Kosi river is swept away every year during flood and the *nullahs* (streams) and small rivulets remain full of water or mud, because of which the study area remains inaccessible on a number of occasions.

Lack of funds prevented extensive surveys in many of the districts where Greater Adjutants were reported earlier. Also, the existing population of Greater Adjutants in the state could not be monitored round the year. General law-and-order is also a problem which prevented surveys in certain areas.

Recommendations

1. Since the main breeding colony is restricted to a very small area in Kosi *diara* there is an immediate need to protect this breeding population, till a few more colonies are established. Else, a single threat factor may eliminate the species from the state.

2. There is a need for a long term project work, at least five years, to protect this breeding population and to study the behaviour of the two adjutant species.

3. Regular monitoring, awareness programmes, and direct protection measures should be taken at both Kosi and Ganga *diaras* to help establish these new breeding colonies.

4. Many breeding sites of Lesser Adjutants, a Vulnerable species, and a single nesting site of Black-necked Stork, a Near-Threatened species, have been observed in this IBA. Continuous awareness programmes will help in the conservation of all these stork species.

5. Special protection measures should be taken at Ashram *tola* where regular incidences of falling nests and high mortality of Greater Adjutant chicks have been observed during the last two seasons.

6. Attention is required at Lakhminia where nests of the breeding Greater Adjutant were disturbed by chopping of trees by the villagers.

7. Movement of Banpar (*Gulgulwas*), a hunting tribe, should be properly tracked, not only to protect the birds from them, but also as they may prove a good source of information.

8. Rescue and rehabilitation centres for the injured birds and chicks should be established at Kosi Kadwa *diara* and the district headquarter of Bhagalpur with a provision for a vehicle to transport the injured birds, and a veterinary doctor trained especially to treat the birds.

9. The local veterinary doctors in the Kosi and Ganga *diaras* should also be trained to treat the birds.

10. Proper monitoring of the population should be done, especially during their congregation.

11. Efforts should be made to notify this area as a Community Reserve under the Wildlife (Protection) Act, 1972.

12. There should be an advocacy to upgrade the status of Greater Adjutant from Schedule IV to Schedule I in the Wildlife (Protection) Act, 1972.

13. Plantation of suitable tree species should be encouraged. Care should be taken that that plants identified as nesting material of the bird should not be destroyed or thrown far away from the nesting sites.

14. Advocacy is needed at local and higher levels; concerned government departments should be involved in conservation programmes. Socio-economic development work should be taken up. Organising programmes like *Garud Mela* (Adjutant Fair) and *Pakshi Mitra* (Friends of Birds) awards every year would encourage the locals to conserve the birds.

15. Regular video documentation would help to study the behaviour of the species.

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NEW DESCRIPTION

A NEW SPECIES OF *BRACHYMERIA* WESTWOOD (HYMENOPTERA: CHALCIDIDAE) ON RICE SKIPPER, *PARNARA GUTTATA* (LEPIDOPTERA: HESPERIIDAE) FROM SOUTH KASHMIR

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Brachymeria masoodii sp. nov., a parasite on rice skipper *Parnara guttata* Bremer & Grey in Kashmir is described and illustrated. A key to the Indian species of *Brachymeria* Westwood, parasitic on rice skippers is also provided.

Key words: *Brachymeria masoodii*, Kashmir, new species, *Parnara guttata*, Rice

INTRODUCTION

Genus *Brachymeria* Westwood is so far known by over 80 species in India including three species, namely *B. intermedia* (Nees), *B. ornatipes* (Cameron) and *B. lasus* (Walker) from Jammu and Kashmir (Narendran 1986; Masoodi *et al.*1986). So far, four species, i.e., *B. albotibialis* (Ashmead), *B. excarinata* (Gahan), *B. jayaraji* (Joseph *et al.* 1973) and *B. nigricorporis* (Husain and Agarwal 1982) are reported from the pupae of *Parnara mathias*, from India. *B. masoodii* sp. nov. has been recorded from *Parnara guttata* infesting rice in Kashmir.

Key to the Indian species of *Brachymeria* Westwood, associated with rice skippers

1. Hind coxa without inner tooth; head without post orbital carina 2
— Hind coxa with inner tooth; head with distinct post-orbital carina 4
2. Frons with distinct preorbital carina; hind tibia mostly black, as long as hind femur, the latter black with 10-12 teeth ..... *B. excarinata* Gahan
— Frons without pre-orbital carina; hind tibia either red or yellowish; hind femur always red; other characters vary 3
3. Hind tibia red in middle and at base; antenna with funicle segments transverse; first tergite of abdomen densely punctate at apical half ..... *B. nigricorporis* Husain & Agarwal
— Hind tibia yellowish; antenna with funicle segments quadrate; first tergite of abdomen finely reticulate ..... *B. jayaraji* Joseph *et al.*
4. Abdomen distinctly shorter than the combined length of pronotum, mesoscutum and scutellum; hind tibia longer than hind femur, the latter with 13 teeth; median ocellus as wide as lateral ocelli; antenna with last two funicle segments wider than long ..... *B. albotibialis* (Ashmead)
— Abdomen as long as or slightly longer than the combined length of pronotum, meso-scutum and scutellum; hind tibia shorter than the hind femur, the latter with 11 teeth; median ocellus distinctly wider than lateral ocelli; antenna with last two funicle segments only slightly wider than long ..... *B. masoodii* sp. nov.

*Brachymeria masoodii** sp. nov.
(Fig. 1a-d)

Female (Holotype): Body black, tegulae yellow; tips of all femur, tibiae, except ventral carina of hind tibia yellow; tarsi light brown with distal segments blackish brown; all coxae black; antennae and wing venation blackish brown; wings hyaline; body pubescent except of eyes, of scrobal area, clypeus, anterior margin of mesoscutum; first abdominal tergite white and setose. Body punctures umbilicate with interspaces smooth, rugose on parascrobal area.

Head: A little wider than maximum width of thorax; scrobes deep, smooth, almost touching the median ocellus, with scrobal edges distinctly raised from general surface and

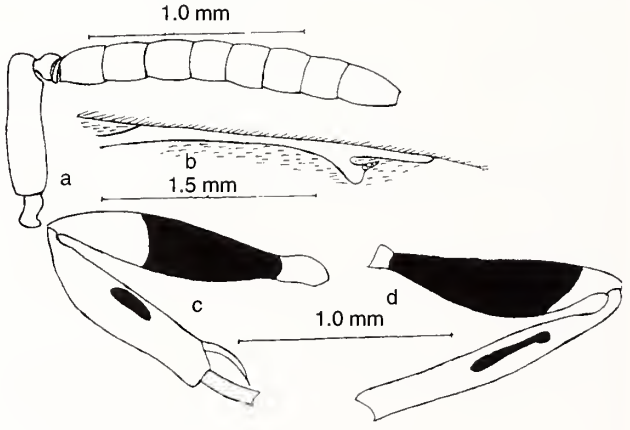

Fig. 1(a-d): *Brachymeria masoodii* sp. nov., female
a. Antenna, b. Part of forewing, c. Part of fore tibia, d. Part of middle tibia

Table 1: Distinguishing characters between *B. albotibialis* and *B. masoodii*

Brachymeria albotibialis (Ashmead)	*Brachymeria masoodii* sp. nov.
1. Body length 3.6 mm.	1. Body length 6.82 mm.
2. Front and mid tibiae without a medial black patch.	2. Front and mid tibiae each with a edial black patch.
3. Eye twice as long as wide.	3. Eye less than twice as long as wide.
4. Interocellar distance two-and-a half times as long as distance between median and lateral ocelli.	4. Interocellar distance slightly over three times as long as distance between median and lateral ocelli.
5. Median and lateral ocelli equal in diameter.	5. Median ocellus wider than lateral ocellus.
6. Antenna with pedicel as long as wide.	6. Antenna with pedicel 1.36 times as wide as long.
7. Antenna with ring segment two- and one- third as wide as long.	7. Antenna with ring segment five times as wide as long.
8. Hind tibia longer than the hind femur.	8. Hind tibia 1.18 times shorter than the hind femur.
9. Abdomen distinctly shorter than the combined length of pronotum, mesoscutum and scutellum.	9. Abdomen nearly as long as the combined length of pronotum, mesoscutum and scutellum (200:202).
10. Abdomen with first tergite shagreen.	10. Abdomen with first tergite shiny smooth.

in front of antennal toruli; parascrobal area thickly setose, rugose; clypeus shiny, smooth, with a row of deep punctures, the latter on head wider than the interspaces, except below scrobes which is finely rugose. Antenna inserted below centre of face, compact, 11-segmented with other characters as in Fig. 1a.

Thorax: Moderately arched; mesoscutum with parapsidal grooves fine, complete, anterior region of mesoscutum transversely rugose, remaining areas punctate; pubescence thick on margin of scutellum, sparsely setose elsewhere on thorax; propodeum with irregular large spaces. Forewing as shown in Fig. 1b. Legs (Fig. 1c,d) with fore- and middle tibiae with a small blackish brown patch medially; hind coxa with outer surface densely punctate, inner area smooth, ventral margin with an inner tooth; hind femur with punctures moderate-sized at its outer margin, finely punctate medially with interspaces shiny and larger than width of punctures; outer margin of hind femur with a row of 11 teeth, 1-6 large, 7-8 small, 9 smaller and 10-11 smallest.

Abdomen: Compact, first gastral tergite shiny smooth, glabrous; ovipositor hidden.

Relative measurements (Holotype) (L:W): Head : dorsally 30:158; facially 108:158; diameter of median and lateral ocelli 14 and 11 respectively; Postocellar length 28; Ocello ocular length 12; eye 75:41; length of malar space 26; inter-ocular distance 76; scrobe 60:44; width of parascrobe 17; diameter of antennal torulus 14; inter-torular distance 11; distance from toruli to clypeus and median ocellus 22 and 65 respectively; scape 63:13; pedicel 7:9.5; ring segment 2:10; F_1 16:13; F_2 15:14.5; F_3 14:15; F_4- F_7 14:15.5; club 21:15.5. Thorax : pronotum 32:115; mesoscutum 85:156; scutellum 85:76; propodeum 25:62; diameter of punctures on scutellum 1.5 times wider than remaining parts of thorax (6:4); forewing 150:348; lengths of submarginal, marginal, post-marginal and stigmal in the ratio of 122:73:29:8 respectively; hind coxa 100:46; hind femur 148:60 and hind tibia 125:13. Abdomen 200:127; length of first and second tergites 74 and 51 respectively.

Female: 6.82 mm long.

Male: Not known.

Holotype: Female, INDIA: J&K; Anantnag, Regional Rice Research Station, Khudwani; ex: pupae of *Parnara guttata* Bremer & Grey, on paddy, 18.ix.2003 (J. Ahmad).

Paratypes: 6 females (Same data as of holotype). 20.ix.2003 (J. Ahmad) (on card). Holotype, and all paratypes are deposited in the National Pusa Collection, IARI, New Delhi.

Holotype and Paratypes: 136/15/45/1. Slide number: 13/6/45/1

Etymology: The species has been named after Dr. Amin Masoodi, ex Director Research, S.K. University of Agricultural Sciences & Technology (Kashmir), Shalimar campus, Srinagar, for his excellent contribution in the field of Agricultural Entomology.

Remarks: The new species resembles *Brachymeria albotibialis* (Ashmead) in many respects, such as colour of tegulae, legs; absence of preorbital carina on frons; maximum width of scrobes in relation to interocular length comparative lengths of malar space and eye; funicle segments F3- F7 subequal etc. (Joseph *et al.* 1973; Table 1), however, following differences between the two are sufficient enough to propose the present species as new one.

ACKNOWLEDGEMENT

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REVIEW

CONSERVING BIODIVERSITY OF RAJASTHAN (WITH EMPHASIS ON WILD FAUNA AND FLORA) Edited by Ashok Verma. Published by Himanshu Publications, Udaipur and New Delhi. 2008. 549 pp. Size: 21.3 cm x 13.5 cm. Hardback. Price: 1,200/-.

This is a book edited by Ashok Verma with nearly 60 contributors. The topics are as varied as "Genetics conservation" to "Orchids of Rajasthan" to "Career and Job Prospects in Wildlife Sciences in India". Some topics have a much wider reach, while others are restricted to only Rajasthan (e.g. Bats of Rajasthan). Ashok Verma is a young field biologist, with a Ph.D. on Harriers, and experience of field work in Keoladeo National Park, and Sariska Tiger Reserve. Presently, he is working with the Wildlife Institute of India as Research Associate. Getting a book, and that also of nearly 550 pages, from him for review was a pleasant surprise. I congratulate him for this work.

The book is a compilation of interesting information about Rajasthan, not necessarily new to science, but at least most of the latest findings about status and distribution of certain species are available in one document. Most chapters are written by known experts, so they are quite comprehensive. Having worked on three major books that needed basic information about species and sites, I know the value of compilation of scattered data. In our country, basic information is sometimes not easily available. I hope books like this will stimulate researchers of other states to compile data of their states.

The book is in four sections. The first section with 12 chapters deals with Biodiversity and Conservation Issues, the second sections deals with Fauna, third with Flora, and fourth with Ecological Sciences. There are five appendices dealing with International Biodiversity Resources, Selected Global Biodiversity Information Centres, Major International Conventions, Central and State Acts, and ENVIS Centres in India. The appendices and some chapters do not give new information, but at least they are available in a book for managers and decisions makers. Now, these people cannot hide behind their usual inane excuse that they do not have information so cannot take conservation actions. Here is a book that gives basic information about the biodiversity of Rajasthan, conservation issues, and national and international obligations.

The book could have been better edited. Many species names are spelt incorrectly (e.g., Houbra instead of Houbara, Wodpecker instead of Woodpecker). Some chapters are reproduced without proper acknowledgement to the source. Some basic information about Rajasthan is repeated in many chapters. However, the most galling mistake is in Chapter 23, 'Status of Vultures in Rajasthan' by Raju Lal Gurjar. Although he admits, albeit by quoting scientific published papers, that diclofenac is "the main killer of vultures in India and Pakistan" (p. 237); he adds, "I also found other reasons to be responsible for vulture decline, i.e., lack of food and dehydration", without giving any concrete evidence. Later, he adds "heavy pesticides use, poisoning genetic depression, human persecution and infectious disease" to be the cause of vulture decline. If he has evidence, then he should publish his 'findings' in a good peer-reviewed journal. He writes "72 White-backed Vultures died in Mahuva, Bhavnagar in Gujarat in June (*sic*) 2005 by dehydration", and quotes Nature Club, Mahuva, and Veterinary hospital as evidence. It is beyond my understanding that in spite of scientific evidence that proves diclofenac as the primary causative agent for decline in vulture population, published in some of the best journals of the world, some people still rant about pesticides, dehydration, mining, cutting of tall trees, etc., as the cause of vulture decline. Publishing unscientific statements based on illogical conclusions in local newspapers does not make a good scientist. Even if the vulture died of dehydration, this dehydration occurred due to damage of the kidneys caused by diclofenac. Why were vultures not dying of dehydration before diclofenac sodium came into veterinary use in 1993-94 in India? Can a long-distance flying bird adapted to live in semi-arid and arid regions dying of dehydration in a normal rainfall year? I cannot believe that the 72 healthy vultures, which Gurjar claims died of dehydration in Bhavnagar district, could not find water in this large district. Admitted, the birds which are ill and exhausted due to kidney failure and visceral gout (due to diclofenac poisoning) may not have the strength to fly in search of water, but scientific logic demands correct conclusions.

I hope Ashok Verma will learn to discriminate between good science and pseudo-science. A good editor selects the writers and chapters carefully. This is not done in this book.

■ Asad R. Rahmani

MISCELLANEOUS NOTES

1. INTERACTION OF THE PIG-TAILED MACAQUE *MACACA NEMESTRINA LEONINA* WITH OTHER PRIMATES IN SOME FORESTS OF ASSAM IN NORTH-EAST INDIA

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The Pig-tailed Macaque *Macaca nemestrina* Linnaeus, 1766, is a relatively poorly documented primate; its elusiveness and furtive behaviour being the main reasons for such poor studies. As such based on field studies, their ecology and social behaviour have been difficult to analyse (Bernstein 1967; Caldecott 1986). Its range extends from North-east India, South-west China, Indo-China and Peninsular Malaysia to several Indonesian islands (from lowland to about 1,300 m altitude) (Groves 1993; Choudhury 2003). The subspecies found in north-east India is *leonina* (Fooden 1975). Groves (2001) proposed full specific treatment for this subspecies. The *leonina* is also known as the Northern Pig-tailed macaque, which is found from North-east India, to Indo-China.

Some of the works available for *leonina* are by Pocock (1931, 1939), McCann (1933), Fooden (1975), Choudhury (1988, 1989, 1993, 1995, 1996, 2002, 2003, 2008), Tilson (1982) and Feeroz *et al.* (1994). Between 1986 and May 2006, several field surveys were carried out in some potential habitats of the Pig-tailed Macaque in North-east India, as a part of a broader survey of wildlife in general. In this note, some interesting observations on interactions between pig-tails and other primate species are presented.

The main observations are from Bherjan-Borajan-Podumoni WS (27°25'-32' N; 95°19'-23' E) in Tinsukia district of eastern Assam. Located on flat terrain (110-130 m above msl), this small sanctuary of three disjunct blocks is covered by partially degraded tropical wet evergreen or rainforest and deciduous plantations.

In its range in northeastern India, the Pig-tailed Macaque is sympatric with at least seven different species of primates, namely loris, three macaques, two colobines and an ape. Almost throughout its range, the Pig-tailed Macaque shares its habitat with the Slow Loris (*Nycticebus bengalensis*), Assamese Macaque (*Macaca assamensis*), Rhesus Macaque (*M. mulatta*), Stump-tailed Macaque (*M. arctoides*), Capped Langur (*Trachypithecus pileata*) and Hoolock Gibbon (*Hoolock hoolock*). In the southern part of its range in the region, it is also sympatric with Phayre's Leaf Monkey (*Trachypithecus phayrei*).

Interactions with Capped Langur, Assamese Macaque, Rhesus Macaque, and Hoolock Gibbon have been observed in the wild during this study. Capped langurs and Pig-tailed macaques were seen nearby without any antagonism. Both were indifferent towards each other; however, they were not seen on the same tree. The Pig-tailed also maintained a peaceful coexistence with Assamese macaques. In fact, the home range of two groups of Pig-tailed macaques is shared with three groups of Assamese macaques in the tiny Bherjan forests (105.5 ha). Whenever the two species were clearly visible to each other, even feeding close by, the adults usually avoided direct eye contact, but the immatures stared at each other. Solitary males were usually not tolerated. Once a solitary Assamese Macaque jumped from a tree to a shrub where some female and juvenile Pig-tailed macaques were feeding, the latter chased the intruder away by squealing and screaming (Bherjan forests; August 01, 1992). The Assamese Macaque group that was feeding close by reciprocated by barks and screams, but with no posture or gesture. On another occasion, an Assamese Macaque moved to a shrub where some female and immature Pig-tailed macaques were feeding, although the former did not show any aggression, the latter fled from the tree uttering low squeals (Bherjan forests; May 31, 1993). The best example of coexistence between these two species of macaques was observed in Bherjan forests on August 15, 1992. A group of Pig-tailed macaques were busy feeding on *Sapium baccatum* fruits, when a group of Assamese macaques came to a nearby tree. The Assamese macaques waited without any agonism, gesture or posture, and made no attempt to chase or disturb the feeding Pig-tailed macaques. It was only when the latter had finished eating that the former took over.

There were a few interesting interactions with lone Rhesus macaques. No sympatric primates, Assamese, Pig-tailed and Stump-tailed macaques, seemed to tolerate the presence of a lone Rhesus Macaque in their vicinity when it tried to approach females of other species. On one occasion the presence of a lone male Rhesus Macaque prevented a group (eastern group in Bherjan forests) of Pig-tailed macaques from travelling through a certain path. The alpha male Pig-tailed Macaque moved first; the Rhesus Macaque

tried to frighten it by violently shaking the branches, but with no success. When he was within 20 m, the Rhesus Macaque fled. Then the whole group moved through behind the alpha male. In the same forest, two Rhesus Macaque males, an adult (it was excited with raised and curled-up tail), and a subadult moved near a group of Pig-tailed macaques, the latter did not panic but barked *hrr, hrr* (July 30, 1993).

In Borajan forest, a subadult Rhesus Macaque male was observed moving towards a group of Pig-tailed macaques that were busy feeding. The alpha male Pig-tailed Macaque immediately reacted by barking *hrr, hrr,* and making threatening gestures and postures. The females and immature screamed (visibly frightened at the sight of just one subadult Rhesus Macaque) – it was a very noisy scene. The Rhesus Macaque did not panic and remained there. It also once made a threatening gesture by leaning forward. The 'aggressive' behaviour continued for about eight minutes, after that the Rhesus Macaque went away 'normally'. In the whole aggression, there was no actual attack (September 10, 1993).

A largely peaceful coexistence was also noticed with Hoolock Gibbon in several sites such as Borajan, Upper Dihing, and Nambor; however, in Bherjan the interaction was extraordinarily noteworthy. When I started observation in Bherjan in July 1992, only a lone female gibbon was there. Since it was alone for at least 3-5 years, it developed a relationship with the Pig-tailed macaques, but not the Assamese macaques. Occasionally the gibbon will make warning growls. The juvenile macaques (not adults) often playfully chase the lone gibbon for a short distance (latter moves away slightly and did not make any attempt to hold ground). They started travelling together, gibbon just following the Pig-tailed Macaque group and also feeding in the same general area.

Some interesting observations were: On July 30, 1992, the Pig-tailed Macaque group (western group of Bherjan forests) and the lone Gibbon were seen sitting in different trees located closeby. No antagonism was noticed; however, when a female macaque came to the same tree and sat near the gibbon, she was driven away. On August 01, 1992, the Gibbon was feeding on a fruit of *Artocarpus chaplasha*, when a subadult Pig-tailed Macaque snatched it, the gibbon did not react. On August 24, 1992, a subadult Pig-tailed Macaque chased the Gibbon playfully, the latter did not react but moved away. On October 03, 1992, while the macaques and the gibbon were together, the latter suddenly started calling at 0830 hrs, the loud call apparently frightened some immature Pig-tailed macaques as they were very near. The screaming of the immature caught the attention of the adult macaques, which uttered warning barks, following which the call of the gibbon also stopped. However, two subadult macaques charged at the gibbon and one of them actually came into physical contact, but without hurting any of them. After this attack the gibbon was never seen with the group during the study period for the next two years.

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2. ADDITIONAL NOTES ON THE DIET OF SLOTH BEAR *MELURSUS URSINUS* IN MUDUMALAI TIGER RESERVE AS SHOWN BY SCAT ANALYSIS

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The Sloth Bear *Melursus ursinus* is a widely distributed omnivore, endemic to the Indian subcontinent. It is a medium-sized mammal weighing between 127 and 145 kg (Prater 1965). Very few studies on its food habits in the Subcontinent have been carried out; Mudumalai (Baskaran *et al.* 1997; Desai *et al.* 1997), Mundanthurai plateau (Gokula *et al.* 1995), Bandipur Tiger Reserve (Johnsingh 1981), Neyyar Wildlife Sanctuary (Srikumaran and Balakrishnan 2002), Panna Tiger Reserve (Yoganand *et al.* 2005), Bandhavgarh Tiger Reserve (Gopal 1991), Chitwan National Park (Laurie and Seidensticker 1977; Joshi *et al.* 1997) and Wilpattu National Park (Eisenberg and Lockhart 1972). The Sloth Bear is a well-known seed disperser, which influences the regeneration of some plant species (Srikumaran and Balakrishnan 2002). Consequently, its movement depends largely on the density and distribution of its key food availability in the area. Sloth Bear population is declining in many parts of its range due to deterioration and loss of habitat (Johnsingh 2003).

Mudumalai Tiger Reserve (11° 32'-11° 43' N; 76° 22'-76° 45' E) is situated at the tri-junction of Tamil Nadu, Karnataka, and Kerala states at an elevation that varies from 960 to 1,266 m. This 321 sq. km reserve is bounded by Wayanad Wildlife Sanctuary on the west, Bandipur Tiger Reserve in the north, and in the south by Nilgiri North Forest Division. According to Champion and Seth (1968), the vegetation types found in Mudumalai are classified into Southern Tropical Dry Thorn Forest, Southern Tropical Dry Deciduous Forest, Southern Tropical Moist Deciduous Forest, Southern Tropical Semi-Evergreen Forest, Moist Bamboo Brakes and Riparian Forest. Earlier studies on food habits of

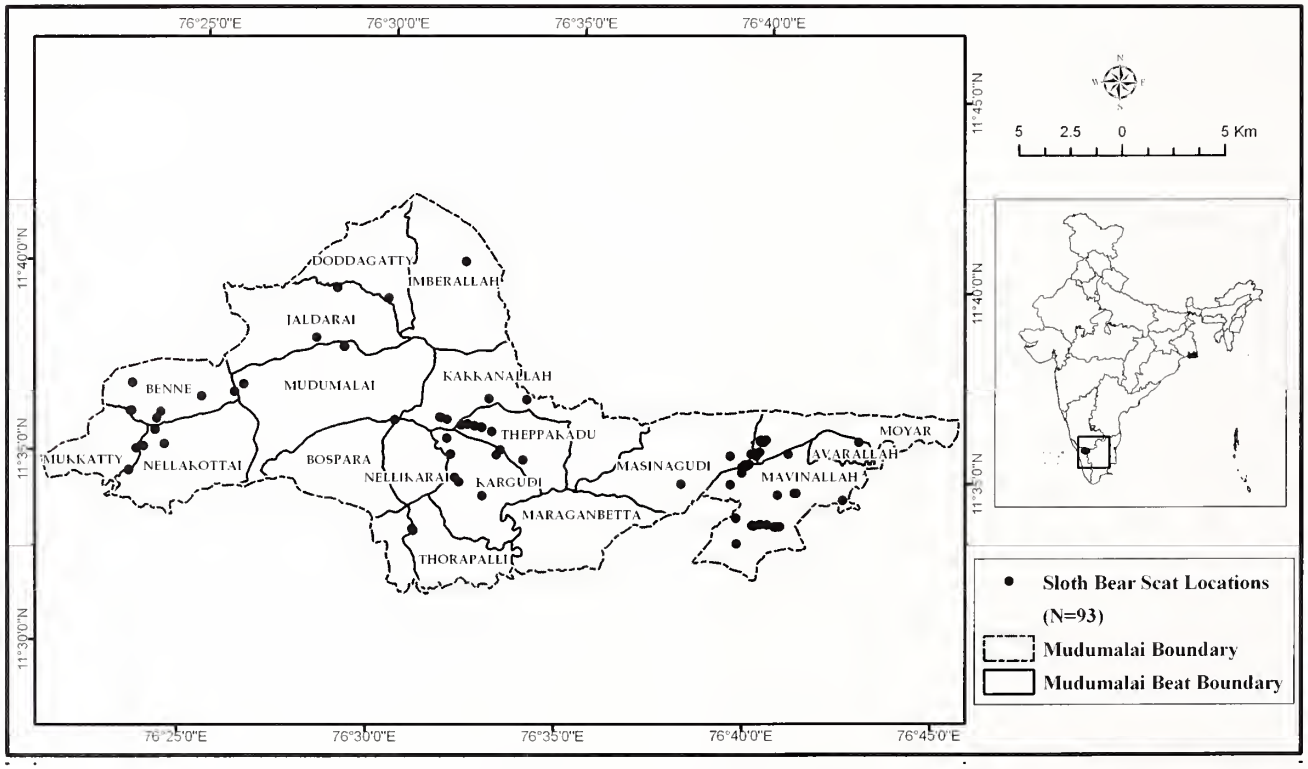

Fig. 1: Locations of Sloth Bear scats collected in Mudumalai Tiger Reserve (January-May 2009)

Table 1: Frequency and percent occurrence of food items found in Sloth Bear scats in Mudumalai Tiger Reserve (January-May 2009)

Plants	Frequency of occurrence	Percent occurrence
Albizzia odoratissma	2	1.0
Anogeissus latifolia	2	1.0
Artocarpus heterophyllus	2	1.0
Cassia fistula	26	13.83
Cordia oblique	12	6.38
Ficus sp.	2	1.0
Grewia tilifolia	4	2.1
Lagerstromia microcarpa	1	0.5
Lantana camara	4	2.1
Mangifera indica	1	0.5
Olea glandulifera	1	0.5
Semicarpus anacardium	1	0.5
Syzygium species	2	1.0
Zizyphus mauritiana	16	8.51
Zizyphus oenoplia	2	1.0
Zizyphus rugosa	2	1.0
Heteropogon contortus	1	0.5
Seteria intermedia	2	1.0
Unidentified fruit	1	0.5
Others		
Family: Formicidae (Red Ant)	30	15.9
Family: Formicidae (Black Ant)	12	6.3
Odontotermes sp.	33	17.5
Order: Coleoptera (Beetle)	6	3.1
Apis sp. and wax	18	9.5
Cervus unicolor	5	2.6

Sloth Bear in Mudumalai (Baskaran *et al.* 1997; Desai *et al.* 1997) were conducted in deciduous and scrub habitats. The present study was carried out in the entire Park covering deciduous, scrub and semi-evergreen habitats in Mudumalai.

Ninety-three Sloth Bear scats were collected along forest roads and trails in the Park encountered from January to May 2009. The location of scats collected is given in Fig. 1. The scats were distinguished by their size, shape, composition of seeds and animal remains, and by using indirect evidences (track, signs). Each scat sample was taken in a separate polythene bag with details of date, place, condition (fresh, old), habitat, and GPS location. The scats were washed in running water using a mesh sieve (1 x 1 mm) and sun dried to recover seeds and animal matter. The plant remains were compared with seeds obtained from plants in the field and identified in the herbarium of the Wildlife Institute of India. Animal remains (bone, hair, insect parts) were identified in the laboratory of the Wildlife Institute of India. The percentage occurrence of various plant and animal remains were assessed.

The frequency and percent occurrence of food items found in Sloth Bear scats is given in Table 1. Thirty-five scats contained plant matter along with animal remains, 40 scats contained only animal matter, and 18 scats contained bee wax remains. A total of 18 plant species were recorded in scats. *Cassia fistula*, *Zizyphus mauritiana*, and *Cordia obliqua* constituted the bulk of the diet with each species contributing 13.83, 8.51 and 6.38% respectively. Two grass species, *Heteropogon contortus*, *Seteria intermedia*, and an unidentified fruit was also recorded. Animal matter in the scats composed mainly of red and black ants (Formicidae), termites *Odontotermes* sp. and bees *Apis* sp. with wax, which constituted 15.9, 6.3, 17.5 and 9.5% respectively. Beetles (Coleoptera) and Sambar *Cervus unicolor* remains (bone, hair) formed a small fraction, 3.2 and 2.7% respectively (Table 1).

The present study documented eight new plant species including a grass species, *Albizzia odoratissma*, *Artocarpus heterophyllus*, *Ficus* sp., *Lagerstromia microcarpa*, *Mangifera indica*, *Olea glandulifera*, *Syzygium* sp., and *Heteropogon contortus*, which were not reported from earlier studies in Mudumalai (Baskaran *et al.* 1997; Desai *et al.* 1997). The percent occurrence of animal matter was found higher than plant matter as compared to previous studies (Gokula *et al.* 1995; Baskaran *et al.* 1997; Desai *et al.* 1997). The occurrence of Sambar remains in Sloth bear scats may be attributed to scavenging behaviour over decayed carcass of wild animals, which has already been recorded by Gopal (1991).

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3. MYSTERIOUS CHARACTERS RECORDED IN BLACK-HEADED IBIS *THRESKIORNIS MELANOCEPHALUS* DURING BREEDING SEASON

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On May 23, 2008, while on a visit to a breeding site of Black-headed Ibis at Paldi village, situated 8 km north of Visnagar, Gujarat, India, we observed three pairs of the Bird busy selecting their nesting site. On approaching closer, we observed red coloration on the bare hind neck of one bird (Fig. 1). Similar coloration was recorded on May 29, 2008, in a bird in a flock of 44 birds at a breeding site at Ralisana village. On June 14, 2008, we observed two birds with red lores and scattered red spots on the throat, besides a red hind neck and mantle, building their nest at Civil Hospital, Visnagar.

Fig. 1: Black-headed Ibis with mysterious characters

During the breeding season, we observed 93 pairs, out of which 17 birds with a red hind neck and mantle, and 3 birds with red lores and scattered red spots on the throat were recorded. The breeding plumage of Black-headed Ibis is well described in literature (Grimmett *et al.* 1998; Gadhvi 2001; Ali 2002; Kumar *et al.* 2005) and there is no mention of any red coloration on body parts during the breeding season.

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4. SIGHTING OF GREY-HEADED LAPWING *VANELLUS CINEREUS* (BLYTH) IN HYDERABAD, ANDHRA PRADESH, INDIA

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A solitary Grey-headed Lapwing *Vanellus cinereus* was sighted at Hussain Sagar (17° 25' 7" N; 78° 28' 3" E) located in the centre of Hyderabad city, Andhra Pradesh, India, twice on January 26, 2008, once on January 27, 2008, and twice on January 29, 2008. It was seen on the northern shores of the lake abutting Sanjeevaih Park. Its grey head, yellow beak with black tip and white secondaries differentiated it readily from the other Lapwings (Red-wattled Lapwing *Vanellus indicus*), which were also present in the area. This is the first record of the Grey-headed Lapwing from Hyderabad.

However, it has been reported earlier from Andhra Pradesh from the following locations:

1. Machlipatnam, Krishna district on February 17, February 23, March 13 and April 03 in 2001 (Conroy 2003).

2. Thatipudi Reservoir, Visakhapatanam district on February 07, 2003 (Aasheesh Pittie, pers. comm. email dated September 02, 2008).

The sighting in Hyderabad seems to be an inland extension of range for the Grey-headed Lapwing, which was earlier reported from the coasts of Andhra Pradesh.

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5. OCCURRENCE AND BREEDING RECORD OF THE FOREST OWLET *HETEROGLAUX BLEWITTI* FROM YAWAL WILDLIFE SANCTUARY, MAHARASHTRA, INDIA

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The Forest Owlet *Heteroglaux blewitti* is one of the least known birds of India. It was considered extinct for 113 years, until its rediscovery on November 25, 1997, by Ben King, Pamela Rasmussen, and David Abbott in Toranmal Reserve Forest of Shahada in Nandurbar district, Maharashtra (King and Rasmussen 1998; Rasmussen and Collar 1998). The Forest Owlet is protected under Schedule I of the Indian Wildlife (Protection) Act of 1972, and is listed as critically endangered.

We were working to prepare a management plan for the buffer zone of Yawal Wildlife Sanctuary in Jalgaon district of Maharashtra situated in the Satpuda Mountain range. The 177.52 sq. km Sanctuary was established in 1969, and is located between Melghat Tiger Reserve and Toranmal Reserve Forest. Since the habitat of Yawal WS is similar to both these reserves, which hold a population of the Forest Owlet (Ishtiaq and Rahmani 2000; Jathar and Rahmani 2004), we speculated the presence of this critically endangered bird in the area.

On May 21, 2004, we were travelling in our vehicle towards the western side of the buffer zone through compartment number 166 (21° 36' 94" N; 75° 53' 147" E). The area is under the jurisdiction of the Forest Development Corporation of Maharashtra (FDCM). The FDCM has carried out Teak *Tectona grandis* plantations in these compartments about eight years ago. The average height of the trees is about 8-10 m. There was very little undergrowth, probably due to the continuous contour trenching (soil and water conservation work) carried out by the FDCM through out the area.

At about 1715 hrs an owlet flew past in front of our vehicle. The plumage pattern and colour of the owlet seemed to be different. We could not locate the bird as it disappeared in the nearby forest. We went in the direction the Owlet flew, but could not locate it. So we decided to play the call of the

Forest Owlet, recorded from Melghat Tiger Reserve by the second author; the call was verified with records at the Bombay Natural History Society. As soon as we played the call, the Owlet immediately responded and came closer to investigate. It sat on a leafless teak *Tectona grandis* tree for about 10 minutes. We continued playing the call and to our surprise at around 1725 hrs one more bird responded to the call. Therefore, in all two birds were present in the vicinity. One of them approached us, up to a distance of *c.* 150 m. We got an opportunity to take some photographs of this individual and carefully observe its plumage. The crown, nape and back were unspotted brown, sharply contrasting with the broadly blackish and white banded wings. The breast looked entirely dull brown, contrasting sharply with the white belly.

We observed another Forest Owlet later in the day close to the site where we first observed it. The belly of the owlet was distinctly blotched. The body colour appeared darker with a stumpy tail. This suggested that the owlet was an immature and that the earlier birds could have been one of the parent birds.

Therefore, we conclude successful breeding of the Forest Owlet in Yawal Wildlife Sanctuary. We have been able to identify the major stress factors in Yawal WS, which would possibly affect the Forest Owlet population in the Sanctuary. The stressors are listed below:

- Clearing of land for agriculture within the Sanctuary, some nesting trees may have been affected.
- Infiltration of villagers from Madhya Pradesh for collection of fire wood and timber.
- Encroachment for agriculture and new settlements within the Sanctuary.
- Forest fires in the Sanctuary.
- Many proposed and existing minor irrigation dams in the last remaining open scrub forest.

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6. ULTRAMARINE FLYCATCHER *FICEDULA SUPERCILIARIS* IN KACHCHH, GUJARAT

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Pingleshwar temple area, on the southern coast of Kachchh, Gujarat, India, has perhaps the largest tall tree groves in the area. During a bird watching trip on October 30, 2008, I came across an Ultramarine Flycatcher *Ficedula superciliaris* in a tree grove at Pingleshwar (area 200 sq. m).

So far, the Ultramarine Flycatcher has been reported from other parts of Gujarat, but not from Kachchh (Ali 1945; Grimmett and Inskipp 1998; Kazmierczak 2000; Rasmusseen 2005). There are five records of this bird from Gujarat (Bakul Trivedi pers. comm.) .

The earlier records were by Bakul Trivedi at Jessore Sloth Bear Sanctuary, Polo Vijaynagar and by Bharat Jethva at Indroda Park, Gandhinagar.

This sighting of the Ultramarine Flycatcher in Pingleshwar temple area is thus a new record for Kachchh.

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7. NEW RECORD OF *BRACHYSAURA MINOR* (HARDWICKE AND GRAY), AN AGAMID LIZARD FROM ORISSA, INDIA

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During the faunistic survey, in and around the Satkosia Wildlife Sanctuary of Orissa, in February, 2009, one dead specimen of *Brachysaura minor* (Hardwicke and Gray) was collected and three others were observed. According to Smith (1935), Sharma (2002) and Das (2002), *B. minor* has hitherto not been recorded from eastern India. Since, compilation of a detailed report will take some time, it was considered desirable to record the extension of the distributional range of the species to eastern India up to Orissa.

Material: 1 (Juvenile); Loc. *c.* 200 m south to Bhurbhura nallah, Labangi, district Angul, Orissa; 21.ii. 2009; Coll. R. Chakraborty. ZSI Registration No. 25833.

Diagnostic Characters: Body feebly depressed, stout, head large; nostrils situated below the canthus rostralis; snout equal or slightly longer than orbit; scales keeled, dorsal ones larger than ventrals; nuchal and dorsal crests are present but not well-developed; two sets of spines above the small tympanum; throat fold present; 11-15 upper and as many lower labials; 48-58 scales round the middle of the body; gular scales either equal or larger than the ventrals; limbs and digits short; tail covered with keeled scales; standard length 53-90 mm; tail not longer than head and body, rounded, slightly compressed, not annulated.

Colour: Dorsal olive-brown, with three rows of dark-brown, light-edged spots on the back and base of the tail; the spots of the middle row are most prominent and rhomboidal; a white stripe on sides of nape, an oblique yellowish stripe from the eye to the angle of the mouth; limbs with dark-brown cross-bars; throat profusely spotted with grey; belly whitish yellow. The juveniles are olive or pinkish brown in colour with dark brown band between eyes.

Habit and Habitat: Terrestrial, crepuscular and nocturnal; in the daytime hides in burrows, usually of rats; sluggish, prefers to rest on stone but can climb up to a metre on vegetation; inhabitants of scrub forest and plains; diet comprises of seeds, insects, and spiders.

Distribution: INDIA: Presently known from Gujarat, Madhya Pradesh, western Uttar Pradesh. **Extralimital**: Pakistan.

Status: Vulnerable (Tikader and Sharma 1992); nothing is mentioned by IUCN (2007).

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8. OBSERVATIONS ON UNUSUAL FORAGING BEHAVIOUR OF *ACANTHODACTYLUS CANTORIS* GÜNTHER, 1864, IN WESTERN KACHCHH, GUJARAT, INDIA

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Survival and reproduction of a species depends on its ability to successfully find and capture the resources on which it lives. Successful foraging behaviour is assumed to be adaptive as it increases survival and reproduction of animals. In lizards, foraging behaviour is studied by various workers (Pianka 1966; Schoener 1971; Huey and Pianka 1981; Regal 1983; Cooper

Fig. 1: *Acanthodactylus cantoris* in the sit-and-wait position of foraging

and Vitt 1989, Cooper 1994; Cloudsley-Thompson 1991; Eifler and Eifler 1999; Wymann and Whitag 2002).

Among lizards, two major modes of foraging are categorised: active, which involves extensive searching or hunting while moving; and sit-and-wait (ambush) foraging (Pianka 1966; Huey and Pianka 1981; Cooper 1994). Actively foraging lizards are characterized by their frequent wandering movements. They eat prey as it is encountered. Active foragers range widely, spend more energy on a daily basis, eat sedentary prey, and are themselves sometimes eaten by sit-and-wait predators. Sit-and-wait foragers remain still for long periods of time, and capture prey as it appears before them. Sit-and-wait predators have small, defined home ranges, eat mobile prey, and seem to have evolved to spend little energy.

Acanthodactylus cantoris Günther, 1864 is a diurnal, insectivorous, terrestrial, and burrowing lizard. In India, *A. cantoris* is reported from Punjab, Haryana, Uttar Pradesh, Jammu and Kashmir, Gujarat and Rajasthan (Verma and Sahi 1995; Sharma 2002). It is a common species in the sandy areas, which includes the desert and coast of Kachchh region. Studies on food and feeding behaviour of *A. cantoris* have been carried out by Krishna and Dave (1959), Chandra and Ahluwalia (1973), Bhatnagar and Bhanotar (1973), Sharma and Vazirani (1977), and Sinha (1985). It feeds on a variety of insects, but termites are the most favoured food item of this lizard. As per our observation, they prefer termites to other insects when both are available. *A. cantoris* is mostly an "active" forager, though sometimes also found to be relying on the "sit-and-wait" mode, i.e., it is a "mixed" forager. In 2008, we observed an *A. cantoris* foraging on the butterflies near a small water puddle of riverine patch of Mata-Na-Madh village area (23° 34' 26.8" N; 68° 52' 36.8" E), in Lakhpat taluka of Kachchh district. The surrounding terrain with gentle undulations was sandy and soft, covered with small pebbles, and has mixed thorn forest vegetation in a nearby area.

The foraging mode of *A. cantoris*, in this case, was sit-and-wait but differed from the usual. The lizard had burrowed itself partially in the sand (Fig.1) near a waterbody and was predating on butterflies that approached near. Total observation period was 13 minutes, during which the lizard repeated this practice four times and got success only twice. This occasional observation contributes some information on the feeding ecology of *A. cantoris*.

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9. FIRST RECORD OF *PROTOBOTHROPS JERDONII XANTHOMELAS* (GÜNTHER, 1889) FROM EAGLENEST WILDLIFE SANCTUARY, INDIA

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While conducting a herpetofaunal survey of the Eaglenest Wildlife Sanctuary, West Kameng district, Arunachal Pradesh, India, during 2006-2008, we encountered four specimens of *Protobothrops jerdonii*. Two (one male, other sex not determined) of the four specimens were found within a gap of twenty minutes at 0930 hrs and 0950 hrs, respectively, at Lama Camp (27.16° N; 92.46° E; 2,350 m) on June 03, 2006. The third and fourth individuals (both males) were also caught at Lama Camp, on June 05 and 06, 2008, respectively. Morphological characters, measurements and colour pattern of all four snakes were recorded and thereafter they were photographed. Three specimens were released and a male specimen (collected on June 06, 2008) was deposited at the State Forest Research Institute, Itanagar, Arunachal Pradesh (S.F.R.I.). On comparing descriptions and keys in Whitaker and Captain (2004), Smith (1943) and Pope (1935), the snake was identified as *Protobothrops jerdonii*.

Gumprecht *et al.* (2004) recognised 3 subspecies of *P. jerdonii*. Analysing scalation data, body colour and pattern, the snakes were identified as *P.j. xanthomelas* commonly referred to as Jerdon's Red-spotted Pit Viper. This subspecies differs from the nominate *P.j. jerdonii* and *P.j. bourreti* in having a differing range of ventrals – 176-188, subcaudals – 54-67 (both fide table – p. 14), and colour pattern of dorsum – predominantly comprised of yellow scales marked with black; always with a dorsal series of rhomboidal or oval brownish-red (usually) or reddish-brown spots (sometimes), some of which join to alternate along the midline of the back (description from images – pp: 129-131). Note: Though the specimen collected had dorsum predominantly black, some scales marked with bright/lemon yellow – almost the opposite of that described earlier, probably this individual is a dark form with the requisite "oval brownish-red spots". It matches well with the other 3 specimens that were recorded from the same area and which conform to the colour pattern in Gumprecht *et al.* (2004).

Gumprecht *et al.* (2004) record *P. jerdonii xanthomelas* from central and southern China, from Henan [*sic*], Shaanxi, Gansu, Sichuan, Guizhou, Hubei and Guangxi Provinces. Though checklists of snakes of the Indian subcontinent (Whitaker and Captain 2004; Das 2003) as well as checklists of Arunachal Pradesh (Pawar and Birand 2001; Athreya 2006)

Table 1: Scalation of *Protobothrops jerdonii xanthomelas* from Eaglenest Wildlife Sanctuary, West Kameng district, Arunachal Pradesh

Scalation	Specimen 1 (male)	Specimen 2 (unknown)	Specimen 3 (male deposited at SFRI)	Specimen 4 (male)
Ventrals	180	173	170	173
Subcaudals	25 (tail incomplete)	59	64	63
Anal	1	1	1	1
Supralabials (L/R)	7/7, 1st completely separated from nasal	7/7, 1st completely separated from nasal	7/7, 1st completely separated from nasal	7/7, 1st completely separated from nasal
Scales between Supraoculars	8	8	7	7
Scales between Internasal and Supraocular (L/R)	2/2	1/1	2/2	1/2
Snout-vent length (mm)	585	760	790	-
Tail length (mm)	43 +? (tail incomplete)	143	136	-
Ratio of tail to total body length	-	0.1583	0.1468	-

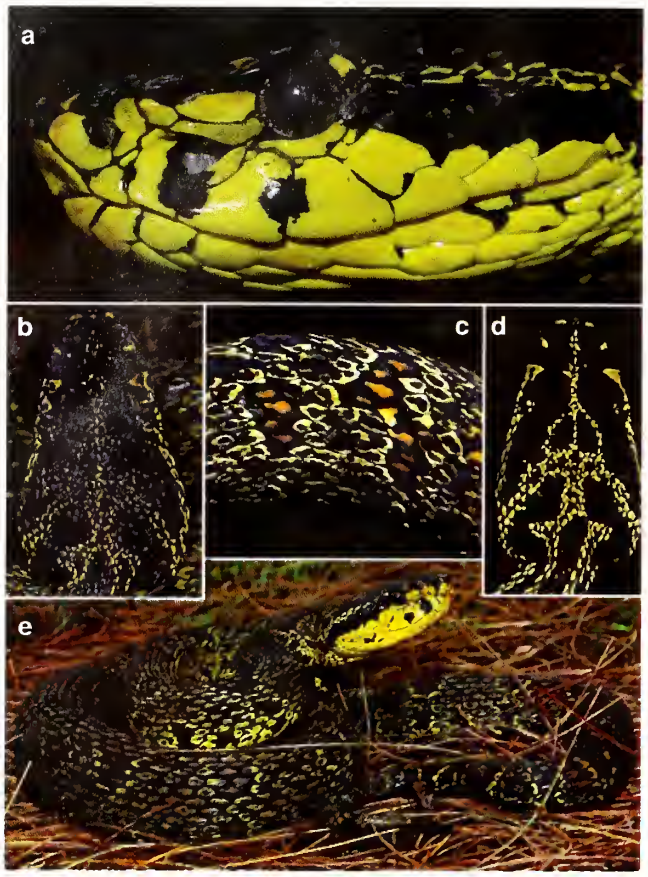

Fig. 1: *Protobothrops jerdonii xanthomelas* (a-e): a. Head (lateral aspect); b. Head (dorsal aspect, collected specimen); c. Mid-body region showing dorsal row of red blotches; d. Head (dorsal aspect); e. General body view

include *P. jerdonii*, none specifically mention this subspecies. We thus conclude this to be probably the first record of *Protobothrops jerdonii xanthomelas* from the present day boundaries of India.

Scalation and measurements are given in Table 1. The following meristic characters: number of dorsal scale rows, (one head length behind head, approximate midbody and one head length before the vent respectively), ventral scales, subcaudal scales, supralabial scales and cephalic scales between supraoculars were recorded. Ventral scales were counted as per Dowling's (1951) method. The number of subcaudals excludes the terminal scale. Specimen 2, 3 and 4 have 173, 170 and 173 ventrals respectively, a slightly lower value than the range given by Gumprecht *et al.* (2004) – 176-188.

Morphology of collected specimen: head distinctly broader than neck; body cylindrical; tail almost 1/7th of the total body length, tail tip pointed. Upper head scales small, unequal, smooth, scarcely imbricate; supraoculars large and entire; first supralabial scale entirely separated from nasal, third largest; a single row of scales between supralabials and the subocular; temporal scales smooth. Dorsal body scales strongly keeled; first dorsal body scale row on either side smooth at midbody (Fig. 1).

Colour and pattern of the collected specimen (in life): dorsum predominantly black, some scales marked with bright/lemon yellow; a dorsal series of subrhombic, irregular brownish-red blotches that are bordered with black; interstitial skin between scales black. *Top of head*: black with symmetrical obscure yellow markings. Supraoculars black with yellow markings. *Sides of head*: lemon yellow with a broad black postocular stripe barely separated from the black dorsal aspect of head by a narrow yellow stripe. Supralabial scales yellow with two black spots-one below the eye, other below the pit. *Underside of head and neck*: bright yellow. *Venter*: anteriormost ventrals dull yellow flecked with black, gradually turning to black, profusely spotted with yellow. Posterior ventrals and tail almost entirely black. *Colour and pattern of the collected specimen (after preservation)*: bright yellow of the body and head cream/dull yellow; brownish-red blotches on the dorsum black.

All the specimens were found at 2,350 m. The habitat was degraded and included nettles, ferns and a species of knee-length grass (species unknown) dominant in the area with a broken pipeline, which made the whole area wet and slushy. Of the four specimens one male (collected) was in the pre-moult condition on June 06, 2008, at 1643hrs and moulted later that evening.

Occurrence of *P.j. xanthomelas* though new to India, is not entirely unexpected as Arunachal Pradesh is adjacent to China and shares similar biotypes. Interestingly, the specimens labelled *P. jerdonii* examined by us at the Bombay Natural History (BNHS) include two specimens, BNHS-2590 (Haka-Chin Hills, Myanmar), and BNHS-2593 (Myanmar-China frontier) which match the scalation of *P.j. xanthomelas*, and suggest the presence of this subspecies in Myanmar – a wider distribution than is currently known. However, fresh collections from Myanmar would be desirable to eliminate the possibility of incorrect locality data. The record of this subspecies from Lama Camp (West Kameng district, Arunachal Pradesh, India) is a range extension of approximately 1,200 km south-west from Sichuan in China – the nearest area where *P.j. xanthomelas* has been previously recorded (Gumprecht *et al.* 2004).

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10. REPORT ON MASS MORTALITY OF FROGS AT SON CHIRIYA WILDLIFE SANCTUARY, GWALIOR, INDIA

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Complete disappearance of amphibian populations in different parts of the world has been reported since 1950 and the frequency of such reports increased sharply during the 1990s (Kiesecker *et al.* 2001; Harp and Petranka 2006). Currently, the rate at which amphibians are going extinct far exceeds the rate for any other vertebrate taxa in the world (Stuart *et al.* 2004). Loss of habitat, introduction of exotic species and exploitation for food, and pet trade are the key threats (Stuart *et al.* 2004). Recent amphibian declines have been reported from species rich tropical forest sites in Central and South America, and Australia, with minimal or no anthropogenic pressure (Alexander and Eischeid 2001; Pounds 2001; Blaustein *et al.* 2003). Infectious diseases partly explain this phenomenon, because it has now been established that pathogens with multiple hosts, biotic or abiotic reservoirs could infect species that are rare and cause disease, and even drive them to extinction (Lips 1999; Lips *et al.* 2006). The chytrid fungus – *Batrachochytrium dendrobatidis*, Iridoviridae group of viruses and pathogenic bacterial strains are known to cause catastrophic mortality of amphibians, decimating wild populations in many parts of the world (Richard *et al.* 2004; Densmore and Green 2007). It has been established that amphibians play an important role in ecosystem function (Whiles et al. 2006), and are sensitive to the quality of their environment (Relyea 2009). For this reason, they are referred to as fortuitous canaries, signalling problems in our environment. It is therefore important that studies on the ecology of amphibians report any adverse impacts on their population.

We present a report on the mass mortality of frogs from a site in Son Chiriya Wildlife Sanctuary. The site is located at Nalkeshwar, Forest Compartment number 373, at Ghatigaon, Son Chiriya Sanctuary, Gwalior, Madhya Pradesh, India (26.2° N; 77.8° E) at an elevation of 240 m above msl. The Sanctuary encompasses an area of 511 sq. km. The site where the mass mortality occurred has a perennial freshwater source from a spring on a hillock. The water trickled into small artificially made puddles that hold water temporarily for use by wildlife in the reserve. The entire area, including the spring and the temporary puddles, was spread over one hectare. It had no human activity and no apparent contamination of freshwater.

The first observation of mass mortality of frogs was made by the staff of the Sanctuary on March 21, 2009, where 30 individuals of the Indian Bull Frog *Hoplobatrachus*

Fig. 1: Bull Frog *Hoplobatrachus tigerinus* with bleeding lesions found in Nalkeshwar, Madhya Pradesh

tigerinus were found dead at the site. On March 28, 60 more frogs of the same species were found dead at the site. On April 05, 2009, 60 more bull frogs were recorded dead and the population of the species had been reduced to 40 individuals. Carcasses of frogs were found along the edge of waterbody and inside the water. An inventory of frogs was carried out on April 25, 2009, using visual encounter survey of the site and was scanned using a powerful torch by one of the observers from 1700 to 1830 hours. All individuals, live and dead, sighted were recorded. Frogs that were dead, diseased and healthy were collected and sealed in plastic bags. The specimens were preserved in -40 °C freezer at the Animal Disease Investigation Laboratory, Department of Animal Husbandry, Gwalior. Eight specimens of diseased *H. tigerinus* collected earlier by the forest department staff were also preserved in a similar fashion for further pathological investigation. Only frogs that showed symptoms of disease were caught and examined for skin lesions, discoloration of skin and ectoparasites. Carcasses observed were examined for any sign of predation.

In all, four frog species were encountered, they were Indian Skipper Frog *Euphlyctis cyanophlyctis*, Paddy Field Frog *Fejervarya* cf. *limnocharis*, Indian Bull Frog *Hoplobatrachus tigerinus*, and Common Burrowing Frog *Sphaerotheca* cf. *breviceps*. The number of frogs of each species encountered during the survey revealed further reduction in the population of bull frogs on the site (Table 1). No tadpoles were observed during the present survey. Diseased frogs had oedema of limbs and phalanges. Small focal ulcers on the skin were observed on the limbs, ventral and dorsal surface of the skin (Fig. 1). The ulcers were wet, open and blood oozed from it when the portion of the body was pressurized. The animal showed poor reflexes and limb movements were impaired, making them almost immobile. Bleeding lesions were also observed on the foot of these frogs. Live frogs representing those that showed these symptoms and those that did not were collected and preserved in the deep freezer (Table 1). It is important to note that all frog species, except *F. limnocharis* showed symptoms of the disease, and no carcasses of this species were recorded from the site. No ectoparasites were observed on the frogs examined during the survey. Dead frogs showed no sign of predation on them.

Based on discussions with amphibian disease experts on this incident the following scenario emerged. There are several diseases that cause heavy mortality in frog populations. Among them, only few infectious diseases are reported to cause mass mortality in wild frogs, they are Ranaviruses (e.g. FV3, tadpole oedema virus) and chytridiomycosis (Densmore and Green 2007). Toxins could also cause mass mortality in amphibians but could be extremely tedious to diagnose. Chytridiomycosis causes ulcers but typically skin changes are mild, with excess shedding being the most consistent sign (Berger *et al.* 1998). Bacterial infections such as red leg have not been found causing mass mortality in the wild (Green *et al.* 2002). Ranavirus cause skin ulcers and haemorrhage (Densmore and Green 2007), although they do not cause lesions identical to those seen in the frogs in Nalkeshwar. It should not be ignored that there are different strains of pathogens causing diseases in different regions of the world, and only a thorough investigation could reveal the pathogen. However, frogs having legs swollen with fluid is often considered a typical symptom of infection caused by Ranavirus (Densmore and Green 2007). They are best diagnosed by isolating on cell culture using standardized protocols (Greer and Collins 2007). During monsoons when frogs breed, they tend to disperse and there is a possibility of

Table 1: Frogs encountered during the survey of April 25, 2009, at Son Chiriya Wildlife Sanctuary

Species	Frogs encountered	Live frogs examined for symptoms and preserved	Live frogs showing symptoms of disease	Dead frogs examined
Euphlyctis cyanophlyctis	141	5	5	8
Fejervarya cf. *limnocharis*	63	4	0	0
Hoplobatrachus tigerinus	14	2	2	2
Sphaerotheca cf. *breviceps*	1	1	1	1

spread of the disease, which is probably localized at present. It is important to investigate thoroughly such stray incidents of mass mortality, because they might be the precursor to an impending disease outbreak in frogs in the region.

ACKNOWLEDGEMENTS

We are indebted for the funding and support from the National Bioresource Development Board of the Department of Biotechnology, Government of India to the project "Barcoding of Anurans of India" (BT/PR82354/NDB/51/141/2006). We would like to thank Sametha Rajora, Madhya Pradesh Forest Department, for inviting our attention and extending support to us. Sanjai Tiwari, Forest Guard, Son Chiriya Wildlife Sanctuary is thanked for assisting us during the survey.

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11. ON A RECORD OF *BADIS BADIS* (HAMILTON) (TELEOSTEI: PERCIFORMES: BADIDAE) FROM TAMIL NADU, INDIA

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India is endowed with a vast fish biological resource representing more than 10% of the world's fish diversity (Das and Pandey 1998). The diversity of indigenous aquarium fish has been documented; however, many species are being indiscriminately caught from their natural habitats leading to their depletion and probable extinction. *Badis* is one such fish which belongs to Family Nandidae and Subfamily Badinae. The first badid species were described by Hamilton (1822) as *Labrus badis* with a lateral line and 17 dorsal spines, and without lateral line and 14 dorsal spines in *L. dario*. Bleeker (1854) established *Badis* as a genus to include these species (Kullander and Britz 2002), which was also recognized by Day (1878). *Badis badis* with highly variable colour was found to be distributed from Pakistan to Myanmar. The genus was revised recently by Kullander and Britz (2002) with the description of 10 new species from the various geographical zones while limiting the distribution of the species *Badis badis* to the lowlands of the Ganges, Brahmaputra and Mahanadi basins, in Nepal, India and Bangladesh. They recognized 2 genera, *Badis* with 12 species and *Dario* with 3 species.

Badis badis is recognised from its congeners (Kullander and Britz 2002) in the combination of the following characters, namely a conspicuous dark blotch covering superficial part of cleithrum above pectoral fin base; absence of dark caudal peduncle blotch; in the presence of a series of

prominent dark blotches along dorsal fin base and a series of dark blotches along middle of dorsal fin; with indistinct bars on sides; in having 25-27 (rarely 28, usually 26) scales in lateral row, in the presence of 19-20 circumpeduncular scales among other characters.

Badis is sometimes called the Dwarf Chameleon Fish due to the considerable colour changes. Predominantly brown with patterned black or red bars, the male will change to a bluish-black pattern with iridescent blue showing in the dorsal, anal, and caudal fins during breeding times and is known only from northern drainages (Menon 1999). The distribution of the species is known to be from Ganges, Yamuna, Brahmaputra (Menon 1999), Godavari drainage (Karmakar and Datta 1998), and from the Mahanadi (Menon 1951). The authentic southernmost limit of *Badis* has been recorded as Mahanadi and Godavari river drainage (Kullander and Britz 2002). A report from Trivandrum, Kerala (Herre 1941), is not vouched in any recent publication. During a fish survey conducted by the first author, *Badis badis* was found in the Chembarampakkam tank in Tamil Nadu. Subadult and adult specimens were collected using a hand dip net in the clear waters in the overflow area of the tank. The fish is beautifully coloured and has bright red edges on the dorsal fin; has a series of prominent dark blotches along dorsal fin base and has indistinct bars on the body. Though there is a record of this species from Bombay (now Mumbai) and Madras by Day (Kullander and Britz 2002), this species has not been previously recorded from any of the drainages of Tamil Nadu (Menon 1999). Day's Madras is the erstwhile Madras Presidency, which also includes parts of Kerala, Andhra Pradesh, Karnataka and Orissa. This fish could have avoided capture in all the previous surveys due to its hiding behaviour in the aquatic vegetation or more likely could have been brought in by the Krishna Water Supply Scheme, which was directly conveyed to Chembarampakkam lake only during January 2007 (Anon 2007).

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We thank Mr. Venkat, Dolphin Aquarium, Chennai, for his help in the collection of the specimen.

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12. TAXONOMIC STUDIES ON SOME SPECIES OF *OXYA* SERVILLE (ORTHOPTERA: ACRIDIDAE) OF KASHMIR HIMALAYA

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Introduction

The grasshoppers constitute an economically important group of insect. A large number of species can damage crops, and they can attack any type of vegetation in any part of the world including forage crops. In this respect grasshoppers compete with cattle. This can affect the farmer's ability to use the pastures effectively. Besides, some grasshoppers feed on the most desirable forage plants in the rangeland, leaving the less desirable plants for cattle. The feeding of grasshoppers if coupled with drought conditions can cause long term

deterioration to the forage plant community. Taking into consideration the economic importance of grasshoppers the present work was undertaken to identify the species causing damage to the forage plants in Kashmir, because correct identification is essential for the evaluation of the damage caused by the particular species and developing suitable control measures. The genus *Oxya* Serville is represented by five species in Kashmir. They feed on paddy, maize or on grass. Some workers, such as Hollis (1971) and Usmani and Shafee (1985), have done taxonomic work on this species, but they have not given the detailed account of the species found in Kashmir region. Some contributions have been made by Sharma and Gupta (1997) and by Bhat and Qadri (1999) on the distribution of species in Jammu and in Dachigam National Park, respectively. In the present study, an attempt has been made to provide a detailed account of the species of the genus *Oxya* Serville.

The specimens were collected randomly from different locations of the Kashmir valley. These spots were selected on the basis of different climatic conditions like temperature, humidity and rainfall, different topography like hills, plains, different altitudes and on the basis of different vegetation. The collected material was preserved in 70% alcohol for the study of genitalia and dry mounting for the study of other characters. To study the different parts of the genitalia, the tip of abdomen was detached and boiled in a test tube containing 10% KOH, after boiling the material was thoroughly washed with tap water and normal process of dehydration was followed, clearing was done in clove oil and permanent slides were prepared in Canada Balsam.

The genus *Oxya* Serville can easily be distinguished on the basis of having lower knee lobe of hind femur spined and toothed ovipositor valves. These insects usually feed in large numbers during August and September in Kashmir. The genus is represented by five species in Kashmir, which can be identified on the basis of the following key.

KEY TO SPECIES OF *OXYA* SERVILLE FOUND IN KASHMIR

1. Posterior ventral basivalvular sclerites of ovipositor without well-defined spine on its lower margin; ventral surface of female subgenital plate concave with lateral longitudinal ridges 2
— Posterior ventral basivalvular sclerites of ovipositor with one or two tooth like spines on its ventral margin 3
2. Female subgenital plate with median pair of spines on posterior margin set close together; male cercus with bifid apex ..... *Oxya grandis* Willemse
— Female subgenital plate with median pair of spines on posterior margin set wide apart; male cercus conical with subacute apex ..... *Oxya velox* (Fabr.)
3. Ventral surface of female subgenital plate with lateral longitudinal ridges bordering a median concavity; posterior margin not smooth 4
— Ventral surface of female subgenital flat or convex, without lateral longitudinal ridges; posterior margin straight and smooth ..... *Oxya fuscovittata* (Marschall)
4. Ovipositor valves with long hook-like dents; posterior ventral basivalvular sclerite with very small spinelets on its inner ventral margin; lateral longitudinal ridges on ventral surface of female subgenital plate spined; male cercus with subacute or truncate apex ..... *Oxya hyla hyla* Serville
— Ovipositor valves with short dents, posterior ventral basivalvular sclerite with a large spine on its inner ventral margin, lateral longitudinal ridges on ventral surface of female subgenital plate with or without spines; male cercus with bifid subacute or truncate apex 5
5 Lateral longitudinal ridges on ventral surface of female subgenital plate with spines along their whole length; males with antennae much longer than combined length of head and pronotum together; cercus with bifid apex ..... *Oxya japonica vitticollis* (Blanchard)
— Lateral longitudinal ridges on ventral surface of female subgenital plate without spines except at apices; males with antennae as long as or slightly longer than combined length of head and pronotum together; cercus with subacute or truncate apex ..... *Oxya japonica japonica* (Thunberg)

***Oxya grandis* Willemse** (Fig. 1)

Oxya grandis Willemse, 1925. *Tijdschr. ent. 68*: 36.

Diagnosis: Antennae as long as or longer than combined length of head and pronotum; tegmina fully developed, anterior margin without spines; male with supra-anal plate having broadly triangular posterior lobe; cercus with bifid apex, epiphallus; with hook-like outer lophi and broad tooth-like inner lophi; ventral surface of female subgenital plate with a long median concavity bordered on each side by a well-developed lateral longitudinal ridge; posterior margin with a pair of small median spines set close together; female ovipositor valves with small dents, posterior ventral basivalvular sclerite without spines on its inner margin.

Material Examined: 1♀, 3♂; INDIA: Kashmir, Baramulla, Safapora on *Oryza sativa*, 9.x.2005 (Shabir A. Reshi); 1♀, Srinagar, Harwan on *Oryza sativa* 13.ix.2006 (Shabir A. Reshi).

***Oxya velox* (Fabricius)** (Fig. 2)

Gryllus velox Fabricius, 1787, *Mantissa Insectorum 1*: 239.

Gryllus chinensis Thunberg, 1815, *Mem. Acad. Petersb. 5*: 253.

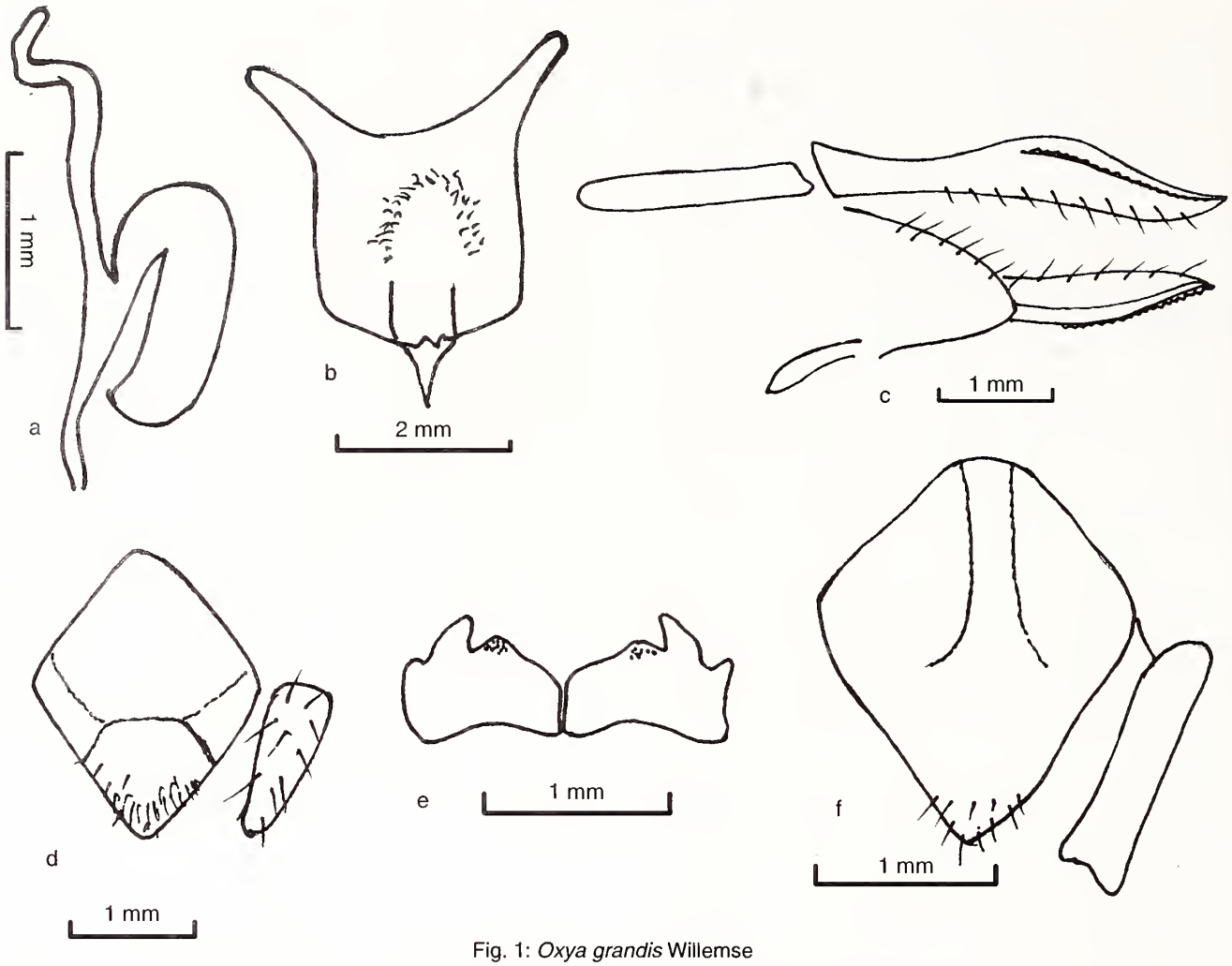

Fig. 1: *Oxya grandis* Willemse
a: Spermatheca, ♀; b: Subgenital plate, ♀; c: Ovipositor valves, ♀; d: Supra-anal plate, ♀; e: Epiphallus, ♂; f: Supra-anal plate ♂

Gryllus squalidus Marschall, 1836, *Ann. Wien. Mus. 1*: 213, Syn. by Hollis, 1971.

Heteracris apta Walker, 1870, *Cat. Derm. Salt. Coll. Brit. Mus.4*: 666, Syn by Hollis, 1917.

Oxya velox Kirby, 1910, *A Synonymic catalogue of Orthoptera 3*: 393.

Diagnosis: Male with supra-anal plate triangular; epiphallus with narrow bridge, ancorae absent, hook-like outer lophi and large tooth-like inner lophi; ventral surface of female subgenital plate with a median longitudinal concavity in the posterior half, bordered on each side by a lateral longitudinal ridge, posterior margin with a pair of median spines set wide apart; spermatheca in females with preapical diverticulum broadly tubular and curved as long as apical diverticulum; ovipositor valves with small and blunt dents, posterior ventral basivalvular sclerite without spines on its ventral margin.

Material Examined: 1♀, Kashmir: Kupwara, Shatgund Payeen on *Oryza sativa*, 10.ix.2004 (Shabir A. Reshi); 4♀, 4♂, Kupwara, Karnah, Gundi Gujran on *Oryza sativa*, 9.ix.2005 (Shabir A. Reshi); 6♀, 11♂, Baramulla, Safapora on *Oryza sativa*, 21.ix.2005 (Shabir A. Reshi); 2♀, 2♂, Srinagar, Dachigam National Park on grass, 23.x.2005 (Shabir A. Reshi).

Remarks: This species has been recorded from Kashmir by Kirby (1914). Sharma and Gupta (1997) recorded it from Jammu region.

Oxya fuscovittata (Marschall) (Fig. 3)

Gryllus fuscovittatus Marschall, 1836, *Ann. Wien. Mus. Naturg, 1*: 211.

Oxy*a turanica* Uvarov, 1912, *Trudy Russk. Ent. Obshch, 40*: 28 Syn. by Willemse, 1925.

Oxya oryzivora Willemse, 1925, *Tijdschr.Ent. 68*: 25. Syn. by Hollis, 1971.

Oryza uvarovi Willemse, 1925, *Tijdschr. Ent. 68*: 27. Syn. by Hollis, 1971.

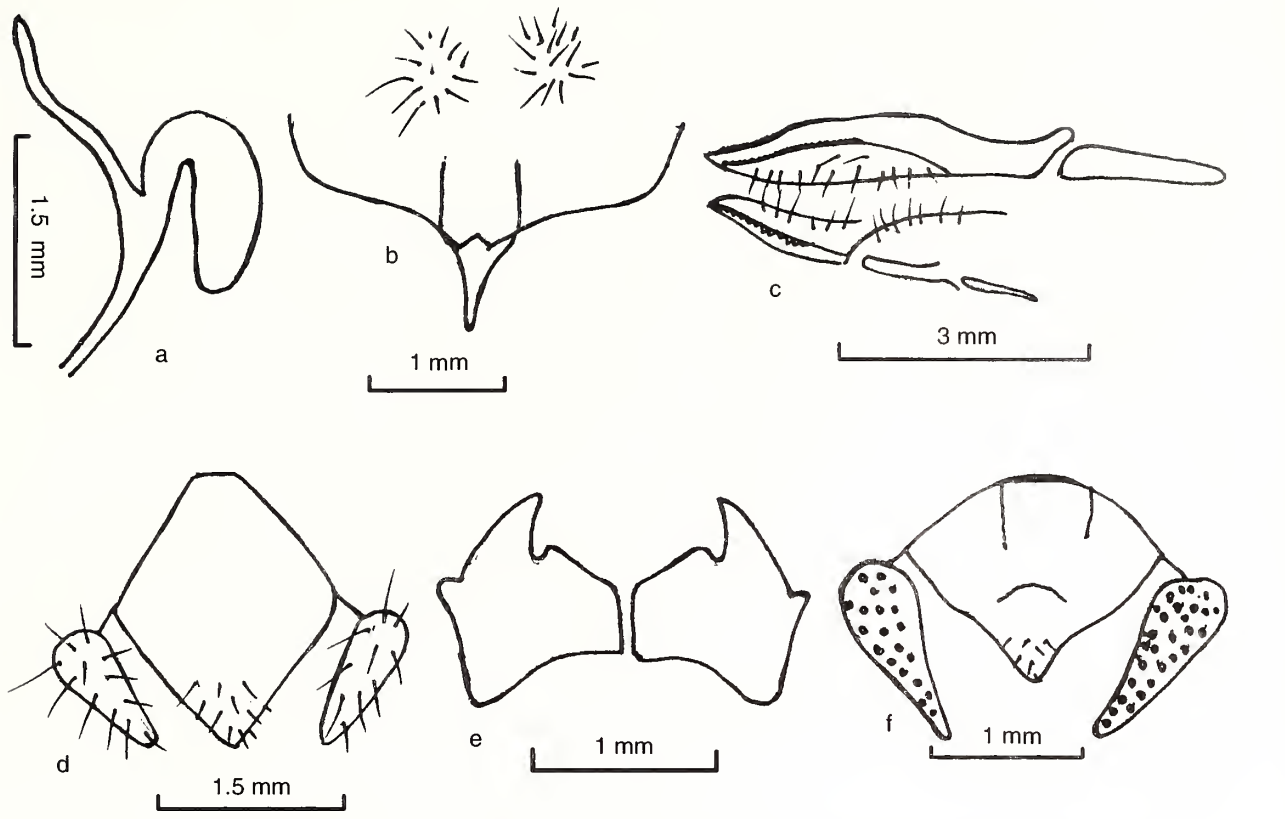

Fig. 2: *Oxya velox* (Fabricius)
a: Spermatheca, ♀; b: Subgenital plate, ♀; c: Ovipositor valves, ♀; d: Supra-anal plate, ♀; e: Epiphallus, ♂; f: Supra-anal plate ♂

Diagnosis: Male having supra-anal plate with lateral projections more pronounced; cercus strongly compressed and bifid; epiphallus with narrow bridge without ancorae and with boot-shaped outer and tooth-like inner lophi, left lophus less developed than the right one; female with subgenital plate flat on ventral surface, posterior margin almost straight and smooth or sometimes with two very small medial spines; spermatheca with apical diverticulum tubular; ovipositor valves with small uniform blunt dents, posterior ventral basivalvular sclerite with small spines on its inner ventral margin.

Material examined: 6♀, 11♂, Kashmir: Kupwara, Shatgund Payeen on *Oryza sativa*, 17.ix.2005 (Shabir A. Reshi); 5♀, 2 ♂, Baramulla, Uri, Uranbuha on *Oryza sativa* 21.ix.2006 (Shabir A. Reshi); 4♀, 1♂, Budgam, on *Zea mays* 10.x.2006 (Shabir A. Reshi).

Remarks: This species has been earlier recorded by Hollis (1971) from Kashmir.

Oxya hyla hyla Serville (Fig. 4)

Oxya hyla Serville, 1831. *Ann. Sci. Nat.* (Zool.) *22*: 287.

Heteracris viridivitta Walker, 1870. *Cat. Derm. Salt. coll. Brit. Mus.* (iv): 662 Syn. by Kirby, 1910.

Heteracris humeralis Walker, 1870. *Cat. Derm. Salt. coll. Brit. Mus.* (iv): 662 Syn. by Kirby, 1910.

Oxya serrulata Krauss, 1891. *Zool. Jb. Syst. 5*: 662 Syn. by Kirby, 1910.

Oxya acuminata Willemse, 1925. *Tijdschr.Ent. 68*: 42 Syn. by Hollis, 1971.

Oxya multidentata Willemse, 1925. *Tijdschr. Ent. 68*: 44 Syn. by Hollis, 1971.

Oxya ebneri Willemse, 1925. *Tijdschr. Ent. 68*: 46 Syn. by Hollis, 1971.

Oxya hyla hyla Hollis, 1971. *Bull. Brit. Mus. Nat. Hist. (Zool) 26*: 282.

Diagnosis: Male having epiphallus with narrow bridge, without ancorae, inner lophi usually well-developed; cercus conical or compressed laterally with subacute apex; female having subgenital plate with a pair of median spines set close together on posterior margin; ventral surface with a median longitudinal concavity which is bordered on each side by a longitudinal ridge bearing short spines, spermatheca with preapical diverticulum tubular, slightly longer and broader than apical diverticulum; ovipositor valves with long hook-like dents, posterior ventral basivalvular sclerites with very small spinelets on its inner ventral margin.

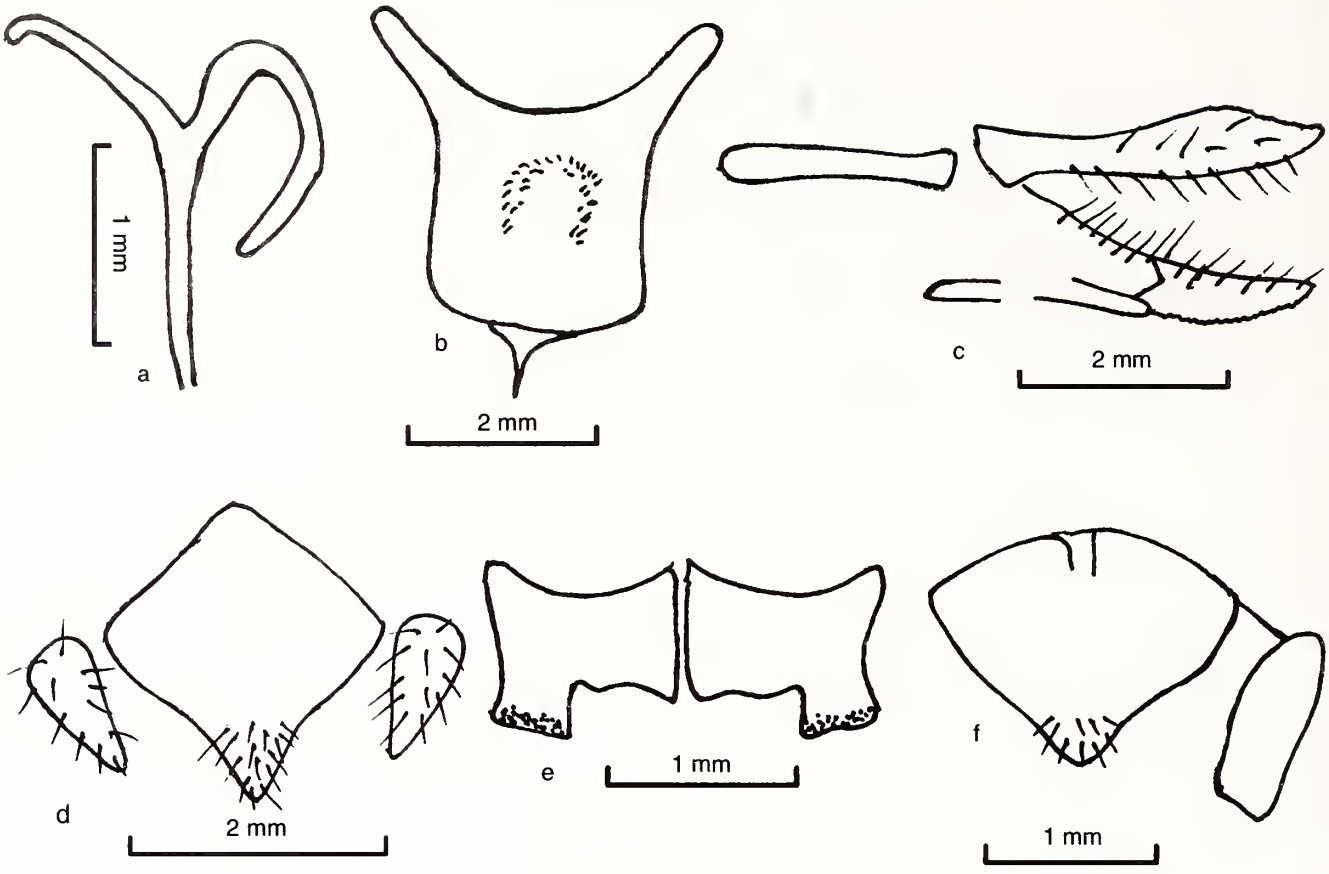

Fig. 3: *Oxya fuscovittata* (Marschall)
a: Spermatheca, ♀; b: Subgenital plate, ♀; c: Ovipositor valves, ♀; d: Supra-anal plate, ♀; e: Epiphallus, ♂; f: Supra-anal plate ♂

Material Examined: 4♀, 5♂, Kashmir: Kupwara, Handwara, Shatgund-Payeen on *Oryza sativa*, 10.ix.2004 (Shabir A. Reshi); 8♀, 11♂, Kurnah, GundiGujran on *Oryza sativa*, 19.ix.2005 (Shabir A. Reshi); 4♀, 2♂, Srinagar, Dachigam National Park on grass, 17.x.2005 (Shabir A. Reshi).

Remarks: This subspecies has earlier been recorded from Kashmir by Bhat and Qadri (1999).

Oxya japonica (Thunberg)

Gryllus japonicus Thunberg, 1824, *Mem.Acad. Sci. St. Petersberg 9*: 429.

Hollis (1971) recognised two subspecies of *Oxya japonica* (Thunberg), on the basis of characters already given in the key.

Oxya japonica vitticollis (Blanchard)

Acridium vitticole Blanchard, 1853, *In*: *Dumont d'Urville, J. Voyage an pole Sud. 4*: 373.

Oxya japonica vitticollis Hollis, 1971. *Bull.Brit.Mus.Nat.Hist.(Ent.) 26*: 307.

Diagnosis: In females lateral longitudinal ridges on ventral surface of subgenital plate with spines all along their length.

Material Examined: 2♀, 3♂, Kashmir: Kupwara, Handwara on *Oryza sativa*, 13.ix.2006 (Shabir A. Reshi); 2♀, 1♂, Srinagar, Shalimar on *Oryza sativa*, 17.ix.2006 (Shabir A. Reshi).

Remarks: This subspecies has been recorded for the first time from Kashmir.

Oxya japonica japonica (Thunberg) (Fig. 5)

Gryllus japonicus Thunberg, 1824. *Mem. Acad. Sci. St. Petersberg 9*: 429.

Acridium sinensis Walker, 1870. *Cat. Der. Salt. Brit. Mus.* (iv): 666 syn. by Hollis 1971

Heteracris straminea Walker, 1870. *Cat. Der. Salt.coll. Brit. Mus.* (iv): 669. syn. by Hollis, 1971.

Heteracris simplex Walker, 1870. *Cat. Derm Salt. Brit. Mus.* (iv): 669. syn. by Hollis, 1971.

Oxya lobata Stal, 1877 *Ofvers. Vetensk. Akad. Forh.*

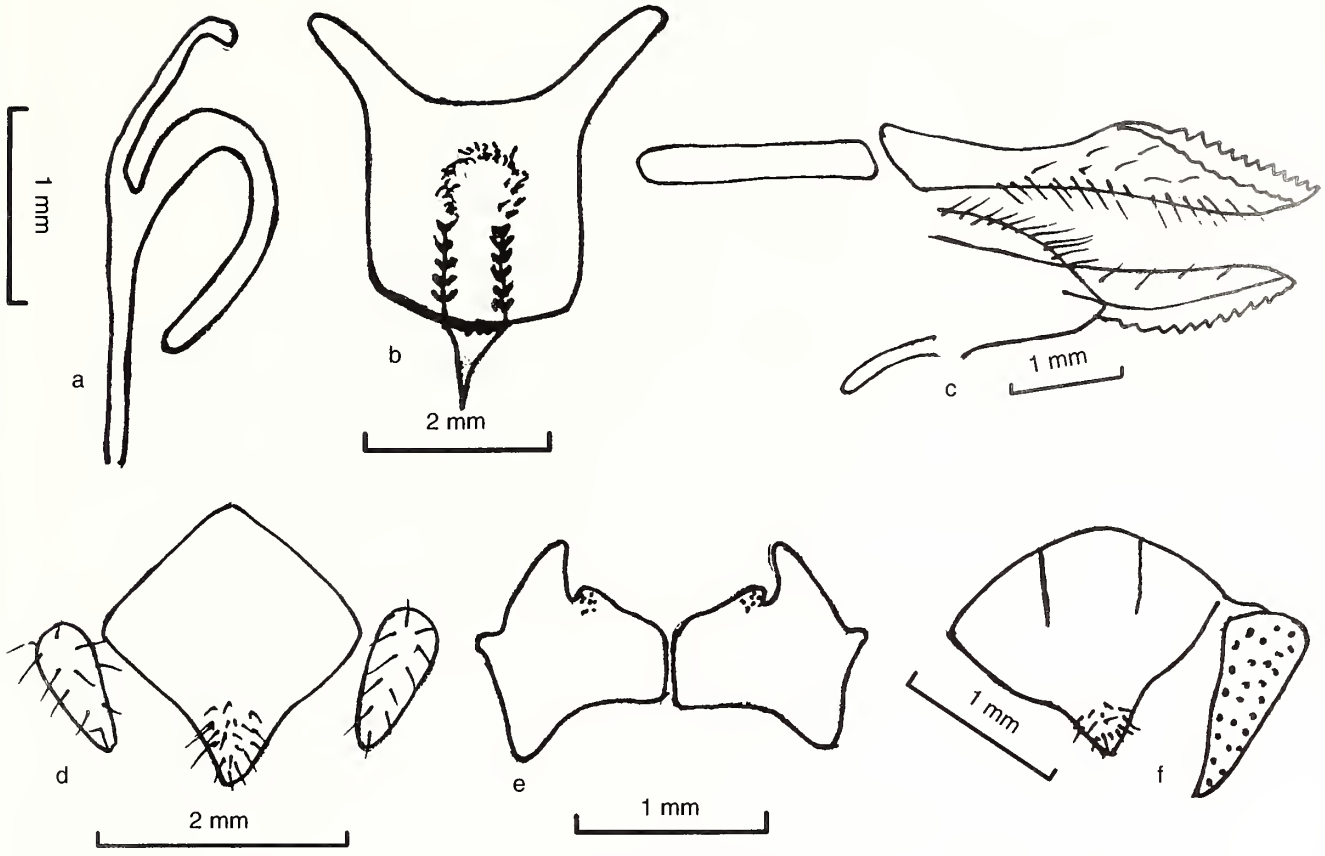

Fig. 4: *Oxya hyla hyla* Serville
a: Spermatheca, ♀; b: Subgenital plate, ♀; c: Ovipositor valves, ♀; d: Supra-anal plate, ♀; e: Epiphallus, ♂; f: Supra-anal plate ♂

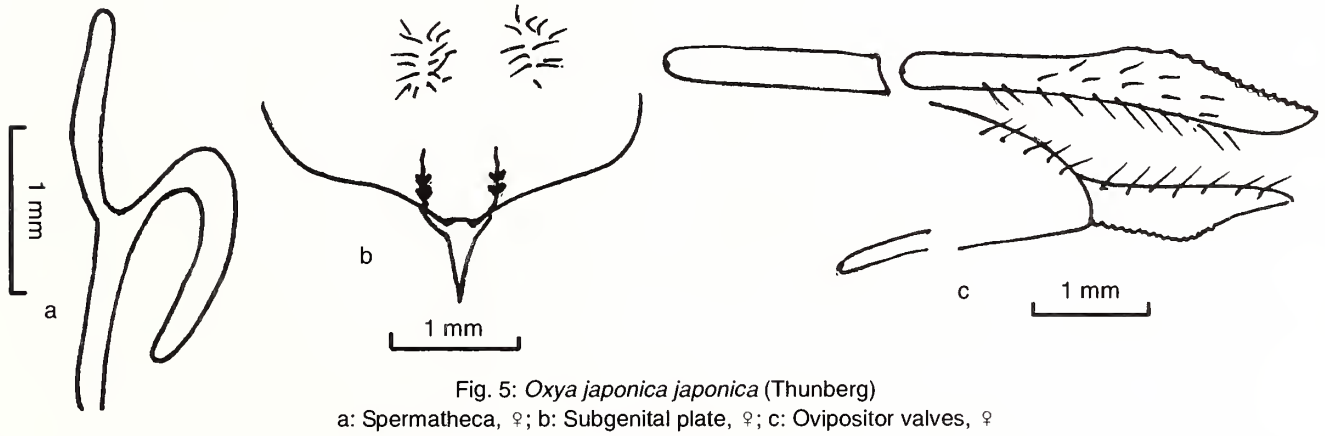

Fig. 5: *Oxya japonica japonica* (Thunberg)
a: Spermatheca, ♀; b: Subgenital plate, ♀; c: Ovipositor valves, ♀

34: 53 syn. by Hollis, 1971.

Oxya sinensis Willemse, 1925. *Tijdschr. Ent. 68*: 23. syn. by Hollis, 1971.

Oxya rufostriata Willemse, 1925, *Tidschr. Ent. 68*: 33. syn. by Hollis, 1971.

Oxya japonica japonica Hollis, 1971. *Bull. Brit. Mus. Nat. Hist. (Ent.) 26*: 302.

Diagnosis: Male cercus with bifid apex; epiphallus with narrow bridge, without ancorae with hook-like outer lophi and short slender inner lophi; female having subgenital plate with a deep median longitudinal concavity along ventral surface bordered on either side by a lateral longitudinal ridge; posterior margin with a pair of median spines set close together; spermatheca with preapical diverticulum tubular, longer than apical diverticulum; ovipositor valves with short dents; posterior ventral basivalvular sclerite with a large spine on its inner ventral margin.

Material Examined: 1♀, 5♂, Kashmir, Kupwara, Handwara on *Oryza sativa*, 13.ix.2006 (Shabir A. Reshi); 5♀, 9♂, Srinagar, Shalimar on *Oryza sativa*, 17.ix.2006 (Shabir A. Reshi).

Remarks: This subspecies has been recorded for the first time from Kashmir

ACKNOWLEDGEMENTS

The authors are greatly indebted to Prof. R.C. Bhagat, Head, P.G. Department of Zoology, for providing research facilities. Thanks are also due to the concerned authorities for granting permission to visit disturbed and restricted areas of the state.

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13. A PRELIMINARY NOTE ON THE MARINE AND ESTUARINE MOLLUSCS IN AND AROUND BAHUDA ESTUARY, ORISSA, EAST COAST OF INDIA

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Marine molluscs of India were well-surveyed right from Preston (1910) to Subba Rao (2003). State-wise series of fauna brought out by Zoological Survey of India also include marine molluscs. Relevant publications also contain systematic works on marine molluscs of Orissa. However, contributions to estuarine molluscs from different estuaries of the state are restricted to Mahanadi (Subba Rao 1968; Subba Rao and Mookherjee 1975; Surya Rao and Maitra 1998) and Rushikulya (Rama Rao *et al.* 1992). Therefore, it was felt necessary to gather information on the molluscs occurring in and around Bahuda, another important estuary in Orissa. The results are presented in this communication.

Bahuda estuary (19° 05' N; 84° 44' E) (Fig. 1) is a minor estuary situated extreme south of Orissa, originates from the Eastern Ghats, meanders through several valleys / plains and finally empties into a shallow lagoon that opens into the Bay of Bengal through a channel of about 5 km length and 250 m width. While the banks of the estuary are sandy, those of the lagoon are muddy with no natural hard substratum around. Of course, some concrete jetties were constructed along the channel that joins the Bay.

Random samples were collected every month from the river mouth and the intertidal zone along the shore in estuarine vicinities, during low tide from January to December 2005. A quadrate frame of 1 sq. m was placed over randomly selected sampling location; sediment up to 10 cm depth was collected and wet sieved with 0.5 mm mesh. Attached forms were removed from the jetties with the help of scalpel, chisel and hammer. All molluscs collected were initially fixed in 5% neutral formalin, later preserved in glycerin ethyl alcohol mixture (1:19) (Gosner 1971). The specimens were subsequently identified up to species level following standard literature (Mookherjee 1985; Subba Rao and Dey 1986; Subba Rao *et al.* 1991, 1992, 1995; Subba Rao and Surya Rao 1993).

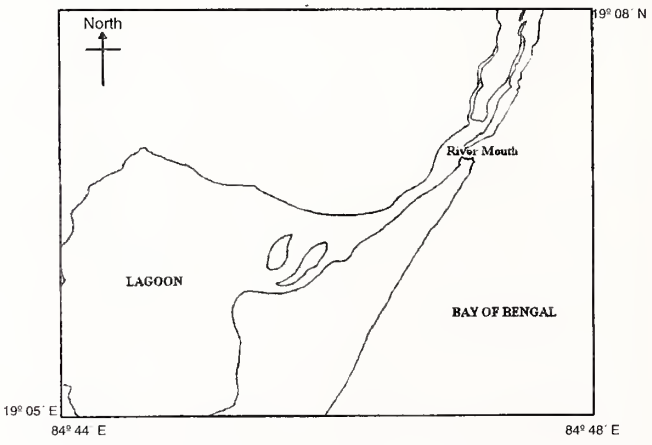

Fig. 1: Map of Bahuda Estuary

During the present investigation, 27 species of molluscs (18 gastropods and 9 bivalves) were collected (Table 1). The 18 gastropod species were represented by 16 genera belonging to 13 families falling under 3 orders, whereas the 9 bivalves were represented by 8 genera belonging to 7 families falling under 4 orders. Of these, the species, namely *Crassostrea cuttackensis* (Newton and Smith, 1912), *Cerithidea* (*Cerithideopsilla*) *cingulata* (Gmelin, 1791), *Telescopium telescopium* (Linnaeus, 1758), *Oliva oliva* (Linnaeus, 1758), *Bullia vittata* (Linnaeus, 1767), *Meretrix meretrix* (Linnaeus, 1758), *Anadara granosa* (Linnaeus, 1758), *A. rhombea* (Born, 1780) and *Siliqua radiata* (Linnaeus, 1758) were common and abundant. However, *Crassostrea cuttackensis* (Newton and Smith, 1912), *Cerithidea* (*Cerithideopsilla*) *cingulata* (Gmelin, 1791) and *Telescopium telescopium* (Linnaeus, 1758) were most dominant.

Among the 48 species reported by Rama Rao *et al.* (1992) from Rushikulya estuary, only 13 species, namely *Cerithidea* (*Cerithideopsilla*) *cingulata* (Gmelin, 1791), *Telescopium telescopium*, *Natica gualteriana* Recluz, 1844, *Murex tribulus* (Linnaeus, 1758), *Babylonia spirata* (Linnaeus, 1758), *Oliva oliva* (Linnaeus, 1758), *Anadara granosa* (Linnaeus, 1758), *A. rhombea* (Born, 1780), *Perna viridis* (Linnaeus, 1758), *Crassostrea cuttackensis* (Newton and Smith, 1912), *Donax* (*Hecuba*) *scortum* (Linnaeus, 1758), *Sunetta scripta* (Linnaeus, 1758) and *Meretrix meretrix* (Linnaeus, 1758) were common to Bahuda estuary. Surya Rao and Maitra (1998) had listed 149 species of molluscs from Mahanadi estuary. Except *Natica gualteriana* Recluz, 1844, *Ficus gracilis* (Sowerby, 1825), *Murex tribulus* (Linnaeus, 1758), *Conus inscriptus* Reeve, 1843 and *Terebra commaculata* (Gmelin, 1791), all the species reported during the present study were common to Mahanadi estuary. However, all the molluscs encountered during the present study were recorded earlier from Orissa except *Terebra commaculata* (Gmelin, 1791) which forms a new record both for Bahuda estuary, as well as Orissa.

Thus, the molluscan diversity in Bahuda estuary can be said to be fairly rich. This abundance is an indirect indication of good productivity of the estuary. Local fishermen depend upon these resources next to fin fisheries for their livelihood. Forms such as *Perna viridis* (Linnaeus, 1758), *Crassostrea cuttackensis* (Newton and Smith, 1912) and *Meretrix meretrix* (Linnaeus, 1758) chiefly contribute to the molluscan fishery and provide an economical and good source of protein to people. Shells of many bivalves and gastropods

Table1: Checklist of molluscan fauna of Bahuda estuary

Class	Order	Family	Species
Gastropoda	Archaeogastropoda	Trochidae	*Umbonium vestiarium* (Linnaeus, 1758)
	Mesogastropoda	Littorinidae	*Littoraria* (*Littoraria*) *undulata* (Gray, 1839)
		Potamididae	*Cerithidea* (*Cerithideopsilla*) *cingulata* (Gmelin, 1791)
			Telescopium telescopium (Linnaeus, 1758)
		Naticidae	*Natica vitellus* (Linnaeus, 1758)
			Natica gualteriana Recluz, 1844
			Polinices (*Polinices*) *tumidus* (Swainson, 1840)
		Tonnidae	*Tonna dolium* (Linnaeus, 1758)
		Ficidae	*Ficus variegata* Roeding, 1798
			Ficus gracilis (Sowerby, 1825)
		Bursidae	*Bufonaria rana* (Linnaeus, 1758)
	Neogastropoda	Muricidae	*Murex tribulus* (Linnaeus, 1758)
		Babyloniidae	*Babylonia spirata* (Linnaeus, 1758)
		Nassariidae	*Bullia vittata* (Linnaeus, 1767)
		Olividae	*Oliva oliva* (Linnaeus, 1758)
			Olivancillaria gibbosa (Born, 1778)
		Conidae	*Conus inscriptus* Reeve, 1843
		Terebridae	*Terebra commaculata* (Gmelin, 1791)
Bivalvia	Arcoida	Arcidae	*Anadara granosa* (Linnaeus, 1758)
			Anadara rhombea (Born, 1780)
	Mytiloida	Mytilidae	*Perna viridis* (Linnaeus, 1758)
	Pterioida	Placunidae	*Placuna placenta* Linnaeus, 1758
		Ostreidae	*Crassostrea cuttackensis* (Newton and Smith, 1912)
	Veneroida	Cultellidae	*Siliqua radiata* (Linnaeus, 1758)
		Donacidae	*Donax* (*Hecuba*) *scortum* (Linnaeus, 1758)
		Veneridae	*Sunetta scripta* (Linnaeus, 1758)
			Meretrix meretrix (Linnaeus, 1758)

in this area are exploited for lime preparation and ornamental / decorative purposes. In view of good abundance of molluscs during the present limited work, further survey(s) are likely to bring to light more species that have not so far been recorded from this region and understand the biodiversity better.

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14. *CROTALARIA ANGULATA* MILLER AND *TAXILLUS BRACTEATUS* (WALL.) TIEGHEM – NEW RECORDS TO THE FLORA OF ORISSA

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Introduction

In the course of phytosociological studies of Similipal Biosphere Reserve, Mayurbhanj district, Orissa, India, we collected specimens of two interesting species. After critical examination (Gamble and Fischer 1915-1936) and examining the specimens deposited at Linnaean Herbarium (S-LINN), Swedish Museum of Natural History (Anon 2002) and Central National Herbarium (CAL), Kolkata, they were identified as *Crotalaria angulata* Miller (Papilionaceae) and *Taxillus bracteatus* (Wall.) Tieghem. (Loranthaceae). They are not mentioned in the flora of Orissa (Saxena and Brahmam 1996; Mishra *et al.* 1999), and are first time records from here.

Crotalaria angulata Miller (Papilionaceae)

Crotalaria angulata Miller, Gard. Dict. ed.8. no.9. 1768. *Astragalus biflorus* L. Mant. Pl. 273. 1771. *Crotalaria biflora* (L.) L. Mant. Pl. 570. 1771: FBI 2: 66. 1876; Gamble 1: 292 (206) 1918.

Prostrate herb. Branchlets hispid. Leaves simple, ovate. 1.0-1.6 x 0.4-1.0 cm, base and apex obtuse, margin entire. Racemes lateral, 2-flowered. Corolla exerted, yellow. Pod subglobose, 1.0 x 0.8 cm, stiff-hispid, twice as long as calyx. Seeds 8-10.

Habitat: Rare, in fringes of Sal dominated moist deciduous forests (elevation: 800 m).

Fl. & Fr.: August-February.

Specimen Examined: Orissa: Mayurbhanj district, Aski: 14.ii.2005, CSR 1991 (North Orissa Univ. Herbarium).

***Taxillus bracteatus* (Wall.) Tieghem. (Loranthaceae)**

Taxillus bracteatus (Wall.) Tieghem, Bul. Soc. Bot. France 42: 256.1895. *Loranthus bracteatus* Heyne ex Wall. in Roxb. Fl. Ind. 2: 220.1824. FBI 5: 213.1886; Gamble 2: 1252(876).1925.

Parasitic, evergreen herb; branchlets tawny tomentose. Leaves orbicular, 1.5-4.0 x 1.5-4.0 cm, 3 or 5 nerved from base, pilose pubescent, base rounded to cuneate. Flowers in axillary fascicles, yellow, scarlet red inside, 1 cm across.

Habitat: Rare, partial stem parasite on *Kydia calycina* on savannah hill tops (elevation: above 1,000 m)

Fl. & Fr.: October-March.

Specimen Examined: Orissa: Mayurbhanj district, Meghasani hill: 12.ii.2005, CSR 1916 (North Orissa University Herbarium).

Note: It differs from *Taxillus cuneatus* (Roth.) Dancer in presence of orbicular leaves and tomentose plant parts and flowers, in case of latter leaves are obovate-spatulate, plant parts and flowers are glabrous at maturity.

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15. *HEDYCHIUM FLAVESCENS* CAREY EX ROSCOE – AN ADDITION TO THE FLORA OF MAHARASHTRA STATE

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Hedychium flavescens Carey ex Roscoe (Family: Zingiberaceae) was recently collected from Tillari region in Kolhapur district of Maharashtra state, and this is the first report of its occurrence in Maharashtra. The species was so far reported from southern parts of India (Sabu 2006). The genus *Hedychium* in Maharashtra is now represented by three species, namely *H. coronarium* Koen., *H. flavescens* Carey ex Roscoe and *H. flavum* Roxb. The identity of *H. flavum* Roxb. is uncertain (Sharma *et al.* 1996). In the present paper, the nomenclature of the species along with a note are given for easy identification.

Hedychium flavescens Carey ex Roscoe, Monandr. t. 50. 1825; Wight, Icon. Pl. Indiae Orient. t. 2008 & 2009. 1853; C.E.C. Fisch. in Gamble, Fl. Pres. Madras 8: 1485. 1928; K.G. Bhat, Fl. Udupi 631. 2003; M. Sabu, Zingiberaceae & Costaceae of South India 199. 2006. *H. coronarium* var. *flavescens* (Roscoe) Baker in Hook. *f.*, Fl. Brit. India 6: 226. 1892.

Specimen Examined: Maharashtra: Kolhapur, Tillari. 05.ix.2006. Malpure 7 (Shivaji University Herbarium).

Note: The species prefers to grow along streams in evergreen forests at high altitude. The major threat to the species is the alteration of habitat and clearing of the forest for cultivation. The species is now cultivated in the Botanic Garden of the Department of Botany, Shivaji University, Kolhapur. The propagules of the species are also distributed for cultivation in home gardens, which can be an efficient practice for conservation of rare wild ornamental plants.

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16. SOME RARE AND ENDANGERED PLANT SPECIES OF GUJARAT, INDIA

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During an extensive survey on the floristic diversity of Saurashtra (2000-2003) some interesting and threatened plants of Gujarat, *Polygala irregularis* Boiss. Diag., *Lotus corniculatus* var. *minor* Baker, *Tephrosia jamnagarensis* Santapau, *Periploca aphylla* Decaisne and *Lepidagathis cristata* Wild were collected; of these the occurrence of *Lotus corniculatus* var. *minor* Baker is a new record to the flora for Gujarat hitherto not recorded from Gujarat sensu Santapau (1962), Shah (1978), and Bole and Pathak (1988). The details of the plants are as follows:

1. ***Polygala irregularis* Boiss. (Polygalaceae)**

While studying the flora of Sutrapada coastal Forest, Veraval, we collected and observed *P. irregularis* in isolated pockets. Cooke (1901) has stated "a rare plant, found in Sind and on coast of Kathiyawad, Gujarat". Whereas Shah (1978) refers to Saxton (no. 3273) collected from Ahmedabad, extremely rare. The plant is rare in the region and requires immediate attention.

Flowering & Fruiting: September-December

Present status: Uncommon

Habitat: Sandy open plains

Specimen examined: BSI 115190, 94791, PSN-SAU 1028 (19.x.2001)

2. ***Lotus corniculatus* var. *minor* Baker (Fabaceae)**

An interesting species of *Lotus* was observed while exploring the flora of Khijadiya Bird Sanctuary (on the bank of Jambuda Lake), Jamnagar. On critically examining the specimen, it was identified as *Lotus corniculatus* var. *minor* Baker. This is a dwarf form of *L. corniculatus* L.; recorded by Hooker (1876) from the plains of Sind with solitary flowers and fleshy leaflets 1/8 inch long. Cooke (1901) has stated the variety with solitary flowers and is confined to Sind only. The present observation extends the earlier known distribution of the species. There is no report of the species in the Flora of Gujarat (Shah 1978) and in that of Saurashtra (Thaker 1910; Santapau 1962; Santapau and Janardhanan 1966; Bole and Pathak 1988). Thus, to refer to its occurrence and habitat, the same has been accounted here (Fig. 1).

Flowering & Fruiting: September-November

Present status: Endangered

Habitat and Ecology: The plant was growing on the clayey and silty saline soil.

Specimen examined: PSN-SAU 1039 (8.x.2001)

3. ***Tephrosia jamnagarensis* Santapau (Fabaceae)**

During a survey of the vegetation of Khad Khambhaliya *vidi* (Grassland), Lalpur, Jamnagar district, we observed an endangered and endemic plant species of Saurashtra *Tephrosia jamnagarensis* (Santapau 1958; Kothari and Hajra 1983; Shah 1983; Nayar and Sastry 1988) at the lower slopes of hillocks. The present collection forms the rediscovery of this very interesting taxon after a gap of almost three decades. Also, it reinstates the endemicity of the species. The plants were observed on the gravel calcareous soil. The species is very rare and endemic to the region. A recent survey showed that the plant does not occur in the earlier stated regions or surroundings, moreover, is encroached by agriculture fields (Nagar 2000; Rao 2002). The rarity of the plant owes to overgrazing, habitat destruction, lack of protection, and probable other biotic factors.

Taxonomic History

The holotype was collected by Santapau for the first time near Rozi in Jamnagar, Gujarat on the October 16, 1945 and was deposited in the Blatter herbarium, Bombay (now Mumbai), India, under the type specimen Santapau 7522. Ahluwalia collected it on August 24, 1954, in flower buds from Victoria Bridge, Jamnagar (Santapau 1962). The specimen was last collected from Bharuch in 1972 (Vyas 1973; Shah 1978).

Flowering & Fruiting: September-November

Present status: Rare in *vidi* (grassland)

Habitat and Ecology: It grows usually on sandy loamy to gravel calcareous soil on the undulating slopes of the grassland.

Specimen examined: H. Santapau: Jamnagar-7522 BLAT (16.x.1945), PSN-SAU 1058 (17.x.2001)

4. ***Periploca aphylla* Decaisne, (Periplocaceae)**

This plant was located at the coastal belt of

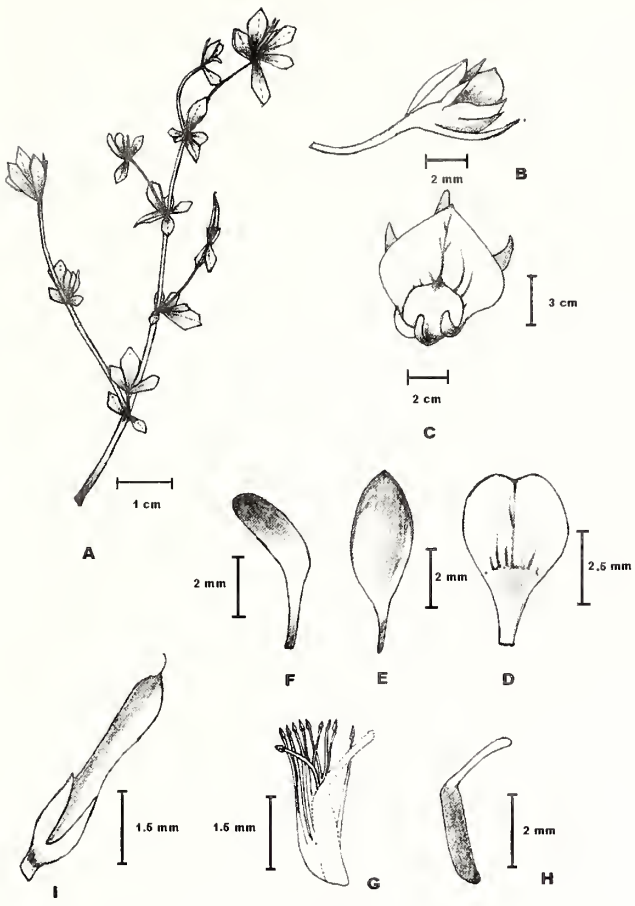

Fig. 1: *Lotus* spp.
A. Habit; B. Flower with Pedicel; C. Flower; D. Vexillum; E. Wing; F. Keel; G. Stamens with Pistill; I. Fruit

Jamnagar. Only few individuals of the same were recorded from the area. Earlier the plant has been recorded from Sind and Kutch (now Kachchh) area (Shah 1978). However, it is first observation to the flora of Saurashtra, Gujarat.

Flowering & Fruiting: August-October.

Present status: Endangered.

Habitat: Sandy and Saline.

Specimen examined: BSI 61964, 32876, PSN-SAU 1234 (8.x.2001)

5. *Lepidagathis cristata* Wild (Acanthaceae)

The plant has been recorded for the first time from Shetrunjaya Hills, Palitana, Saurashtra. Earlier the plant was recorded from north Gujarat (Idar) on old walls of the fort and hilly slopes (Shah 1978).

Flowering & Fruiting: October-December

Present status: Uncommon.

Location: Shetrunjay Hills, Palitana, Bhavnagar district.

Habitat: Shade of scrubby vegetation in the slope and along the rocky riverine area.

Specimen examined: G.L. Shah: N.Gujarat-57062 BLAT (1978), PSN-SAU 1339 (31.x.2001).

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CONTENTS

EDITORIAL 133

ON THE DIURNAL ADVERTISEMENT CALL FREQUENCY OF *HEMIDACTYLUS FRENATUS* WITH ADDITIONAL REMARKS ON THE DISTRESS CALL AND CHURR CALL
Dieter Gramentz 135

EARLY STAGES OF THE TRAVANCORE EVENING BROWN *PARANTIRRHOEA MARSHALLI* WOOD-MASON (SATYRINAE, NYMPHALIDAE, LEPIDOPTERA), AN ENDEMIC BUTTERFLY FROM THE SOUTHERN WESTERN GHATS, INDIA
S. Kalesh and Satya Krishna Prakash 142

A NEW REPORT OF *CEPHRENES ACALLE* HOPFFER (LEPIDOPTERA: HESPERIIDAE) FROM SOUTHERN WESTERN GHATS, WITH NOTES ON ITS NATURAL HISTORY AND IMMATURE STAGES
S. Kalesh and Satya Krishna Prakash 149

FAUNAL DIVERSITY OF CLADOCERA (CRUSTACEA: BRANCHIOPODA) OF LOKTAK LAKE (A RAMSAR SITE), MANIPUR (N.E. INDIA)
B.K. Sharma and Sumita Sharma 156

OPISTHOBRANCH FAUNA OF LAKSHADWEEP ISLANDS, INDIA, WITH 52 NEW RECORDS TO LAKSHADWEEP AND 40 NEW RECORDS TO INDIA: PART 1
Deepak Apte 162

BREEDING ECOLOGY AND NEST-SITE SELECTION OF YELLOW-BROWED BULBUL *IOLE INDICA* IN WESTERN GHATS, INDIA
P. Balakrishnan 176

DIVERSITY OF SPIDERS IN GROUNDNUT CROP FIELDS IN VILLAGE AREA OF SAURASHTRA REGION
Varsha Trivedi 184

DISCOVERY OF A BREEDING GROUND OF THE GREATER ADJUTANT *LEPTOPTILOS DUBIUS* AND THEIR CONSERVATION IN THE FLOODPLAINS OF BIHAR, INDIA
Arvind Mishra and Jai Nandan Mandal 190

NEW DESCRIPTION

A NEW SPECIES OF *BRACHYMERIA* WESTWOOD (HYMENOPTERA: CHALCIDIDAE) ON RICE SKIPPER, *PARNARA GUTTATA* (LEPIDOPTERA: HESPERIIDAE) FROM SOUTH KASHMIR
Md. Jamal Ahmad 198

REVIEW 201

MISCELLANEOUS NOTES 202

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